Rhodora

JOURNAL OF

THE NEW ENGLAND BOTANICAL CLUB

Vol. 40. April, 1938. No. 472.

THE POSTGLACIAL HISTORY OF VEGETATION IN NORTHWESTERN WISCONSIN

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Introduction

The Quaternary history of vegetation in the United States has been studied from many angles and the general features are agreed upon by botanists. These investigations have been, in the past, confined largely to macroscopic studies of fossil plants and to a study of the present distribution of floral elements. Within the last decade, attention has been drawn to the value of microscopic examination of peat deposits as an aid to the unravelling of the many problems of Pleistocene and post-Pleistocene plant distribution. These studies have been widely made in Europe and also to a lesser degree in America. The results in Europe have been definite enough to convince the ecologist that this method is one of value in determining the succession of plants in a region.

The present study was begun in the summer of 1929, in Douglas County in the northwest corner of Wisconsin. This county was chosen for the following reasons: (1) It has a post-glacial history that can be divided into definite periods, during which plants could have lived. These periods were associated with the controversial northern end of Glacial Lake Grantsburg, glacial lakes Duluth, Algonquin, and the Nipissing Great Lakes. (2) These lakes, except for the Nipissing Great Lakes, covered more of Douglas County than does the present Lake Superior and it has been possible to secure peat materials associated with each of these lakes. (3) There is considerable geological and botanical literature at hand dealing with the basic problems of geology and botany in Douglas County.

During the investigation an attempt was made to trace or determine in Douglas County (1) the vegetational succession from the earliest post-glacial time to the present, (2) the date of appearance of certain plant species by a comparison of peat deposits associated with the various lakes, and (3) to compare the fossil spectra and the present ecological succession on the various soils of Douglas County.

Methods: The methods used in this study were essentially the same as used by others engaged in like investigations. The collection of materials for study was accomplished by the use of a Davis Peat Sampler, a Hiller Peat Sampler, or by digging and carefully cutting samples of peat out of the walls of the test pits. The three methods of securing peat, when checked against one another, gave the same results. The first method was found to be the most rapid and the last the most reliable.

The bogs or peat deposits chosen for study were usually less than one acre in area. The reason for this choice becomes significant when one examines the conditions where peat is now accumulating in water. Bog lakes at the present time that are larger than one or two acres in area often present complicated problems of sedimentation, which are likely to confuse and destroy the regular deposition of the finely divided sediments. These conditions are minimized by working smaller peat deposits and the results have been found to be very satisfactory. It is also usually possible to dig into the smaller deposits and to examine in greater detail the materials of the lowest horizons.

Peat samples were secured from two, three, or four borings or test pits in the deepest part of each bog. Samples of peat were taken at various depths and the intervals were determined largely by the depth of the deposit. The lowest samples were taken about one inch below the contact of peat and the mineral soil. These usually did not contain fossils. Samples were always taken at the contact of the peat and mineral soil, and contained fossils. Other samples were collected at intervals varying in distance from one-half inch up to ten inches apart. The highest sample was taken from the surface of the bog. In this country it has not been the general practice of investigators to examine peat from the surface of the bog. This is unfortunate, for the one possible means of comparing the living flora and the relative abundance of pollen on the bog's surface with the fossils throughout the profile is neglected. Draper ('29) states, "It should be noted that counts from the upper level of any bog are of questionable value because of the chance of oxidation by drainage or by burning." The present study has shown that the upper levels in a bog are reliable indicators of the flora under normal conditions.

The peat specimens were preserved in vials containing a solution of 30% alcohol. This method of storing the peat was found to be more satisfactory than drying. Peat preserved in alcohol is easily studied and the microfossils appear to suffer less destruction in their subsequent preparation than when the peat has been previously dried.

The following schedule was used in preparing the samples for microscopic examination. Approximately 16.4 cc (one cubic inch) of moist peat was thoroughly broken up in 500 cc of distilled water and boiled for three minutes. The mixture was allowed to cool and 10 cc. of normal solution of sodium hydroxide was added to it and then thoroughly stirred. When the peat was of a fibrous or gritty nature it was passed through a one millimeter mesh screen and the residue washed several times with the filtrate. At this point enough saffrin stain was added to slightly color the fossils. This was determined by test slides. The filtrate was then centrifuged and the collected material transferred to 40 cc of glycerine jelly and dehydrated in a desiccator. Next the mixture was melted by placing the container in hot water. The sample was again thoroughly stirred, and with a glass rod, enough solution was placed on each of five labelled microscopic slides to float a number one cover glass. Each slide, as it received its cover glass, was quickly turned over and placed horizontally in a rack to cool.

Examination of the slides was done under a microscope using a 10× ocular and a 16 mm. objective. The slide was controlled with a mechanical stage and artificial light was used entirely for illumination. Two hundred fossils were counted for each horizon. Usually fifty fossils from each of four slides were counted and added to the total to bring the count up to two hundred.

The most satisfactory method of recording the species and abundance of microfossils was found to be with a typewriter. This was set up at the side of the microscope and adjusted to record only fifty letters or figures in a row. A convenient code was established with certain letters or figures representing certain fossils. With this method of recording the slides of one level can be listed and totaled all on one page and can constitute a permanent record for the files. Ordinarily, much eye strain is encountered while making records in writing, but that is reduced to a minimum with the use of a recorder such as a typewriter.

Unknown fossils have been drawn with the camera lucida and preserved for reference and study. Their positions on the slides have been encircled with a china-marking pencil to facilitate easy reference.

In the identification of the microfossils constant reference was made to pollens, spores, and trichomes of recently collected plants whose parts had been treated with sodium hydroxide and stained in a manner similar to the peat fossils. Measurements were made with an ocular measuring disk.

In the tables showing percentages of microfossils in 10 bogs of Douglas County, Wisconsin, the depths in inches are given in italics at the tops of the columns.

Geology

Douglas County comprises approximately 1500 square miles in the northwestern corner of Wisconsin. It lies at the west end of Lake Superior and part of the county is within the lowland adjoining the lake. The topography is of two distinct kinds and upon this basis the county is divided into two geographical provinces, the Lake Superior Lowland, and the Lake Superior Upland. The division of these is given by Martin (p. 431, '32) as the highest abandoned beach line on the south shore of Lake Superior (Fig. 2). The lowland is essentially a plain, sloping gently toward the lake, and trenched by streams to a depth of 25 to 100 feet. The upland is rolling and rugged with morainic features, pitted outwash plains, and large areas of poorly drained topography on which swamps and bogs have developed. The existence of these geographical provinces is due to the presence of a graben at the west end of Lake Superior, which depressed the Upper Keweenawan sandstones below the level of adjacent trap rocks (Martin, p. 429, l. c.). This is supposedly of Pre-Cambrian age and was subsequently filled with sediments and then excavated by water and ice erosion into its present general condition. The soils of the lowland are largely clay and silt with a distinctively red color. The origin of these is lacustrine and they were deposited in the glacial lakes which formed upon the retreat of the ice sheets. The soils of the upland are heterogenous. In the areas of moraines they are rocky and contain a mixture of sand, silt, and clay. In the areas of outwash they are sandy (see soil map, Fig. 1).

The complete Pleistocene history of Douglas County is not yet clearly understood and entirely agreed upon by geologists; however, it is possible to give a general outline of the events, at least during the latter part. Although drift earlier than the Third Wisconsin or Cary Substage is not known in Douglas County, it seems reasonable to conclude that the region was traversed by ice during most of the glacial stages. Leverett (Fig. 5, p. 19, '28) has mapped the drift in the southern part of the county as Third Wisconsin Substage (Cary) and that in the central and northern part as Fourth Wisconsin Substage (Mankato). Upon further investigation these drifts may prove to be the Fourth and Fifth Substages respectively.

After the last Cary Ice had melted back there was evidently a period during which glacial lakes formed along the margins of the retreating ice front. Of these in northern Wisconsin, Martin (pp. 453–454, '32) makes reference to a so-called "Glacial Lake Rouge" and to a "Glacial Lake Sioux" farther east in the Lake Michigan basin. These two lakes are better known as Early Lake Duluth and a stage of Early Lake Chicago respectively. The first formed in the same basin occupied later by Glacial Lake Duluth and according to Martin probably drained by the same outlet. With the continued retreat of the ice this lake and another, Glacial Lake Milwaukee (Early Lake Chicago), in the Lake Michigan Basin coalesced and formed what he calls "Glacial Lake Sioux." Following the formation of "Glacial Lake Sioux" there was another advance of the Wisconsin Ice Sheet (Mankato), with one lobe entering the state and Douglas County from the north while another lobe entered Wisconsin southwest of Douglas County, from the northwest. Martin further states that, "The interval between the termination of Glacial Lake Sioux and the readvance was sufficiently long for the growth of forests." He refers to the forest bed at Two Creeks, Manitowoc County, Wisconsin, and those in the Fox River Valley for this proof (Martin p. 268, l. c.).

That there was an interval between the two Wisconsin substages in Douglas County during which glacial lakes existed and forests flourished is strongly suggested by two fossil logs collected near Solon Springs on the west shore of Lake St. Croix in Government Lot No. 4, Section 18, Township 45 North, Range 11 West. These logs were buried beneath eight feet of river gravel of which the lower part resembles a hard-pan formation. They were discovered by Mr. George Schunning of Superior, Wisconsin, while drilling a well, but

FIG. 1

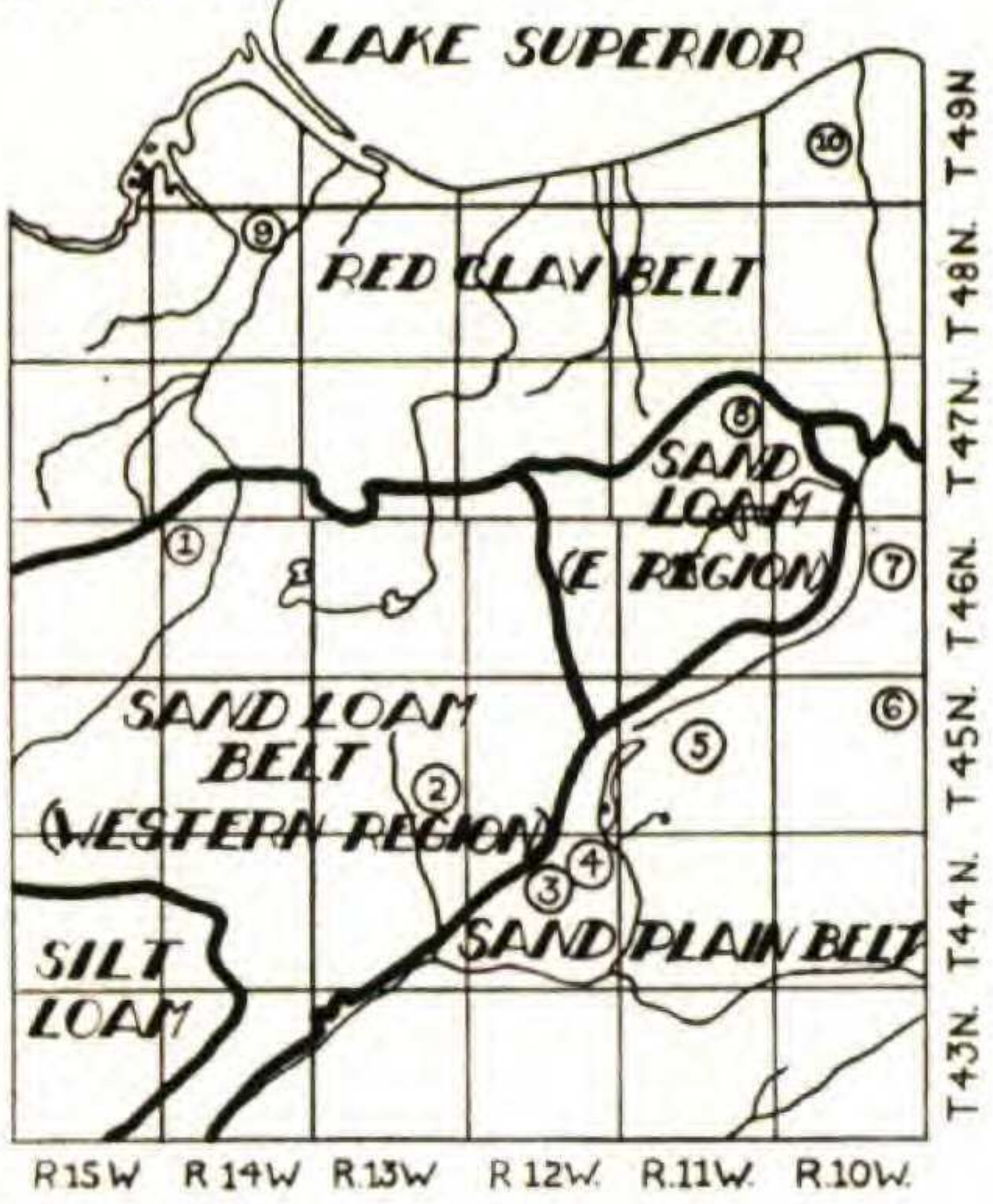


FIG. 2

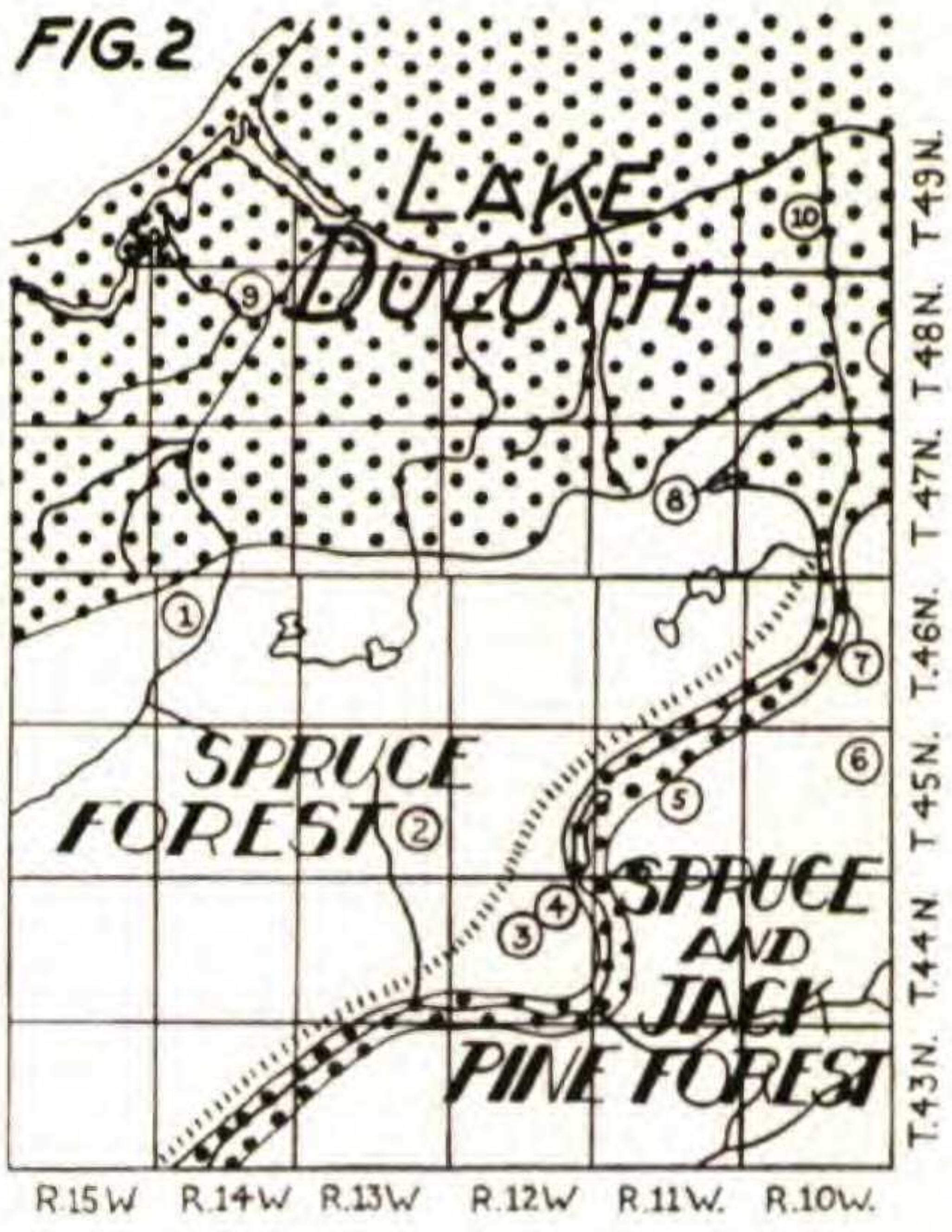


FIG. 3

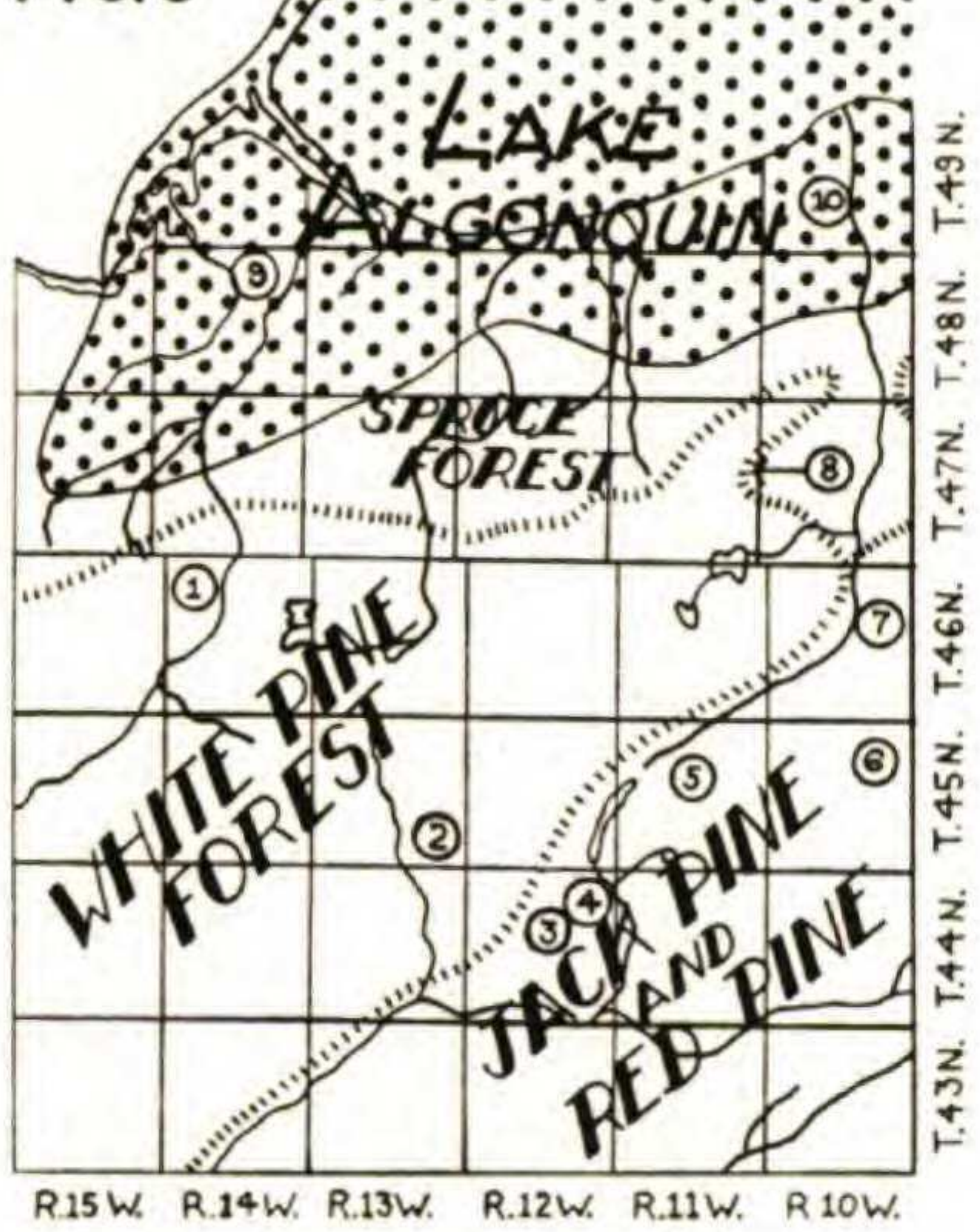


FIG. 4

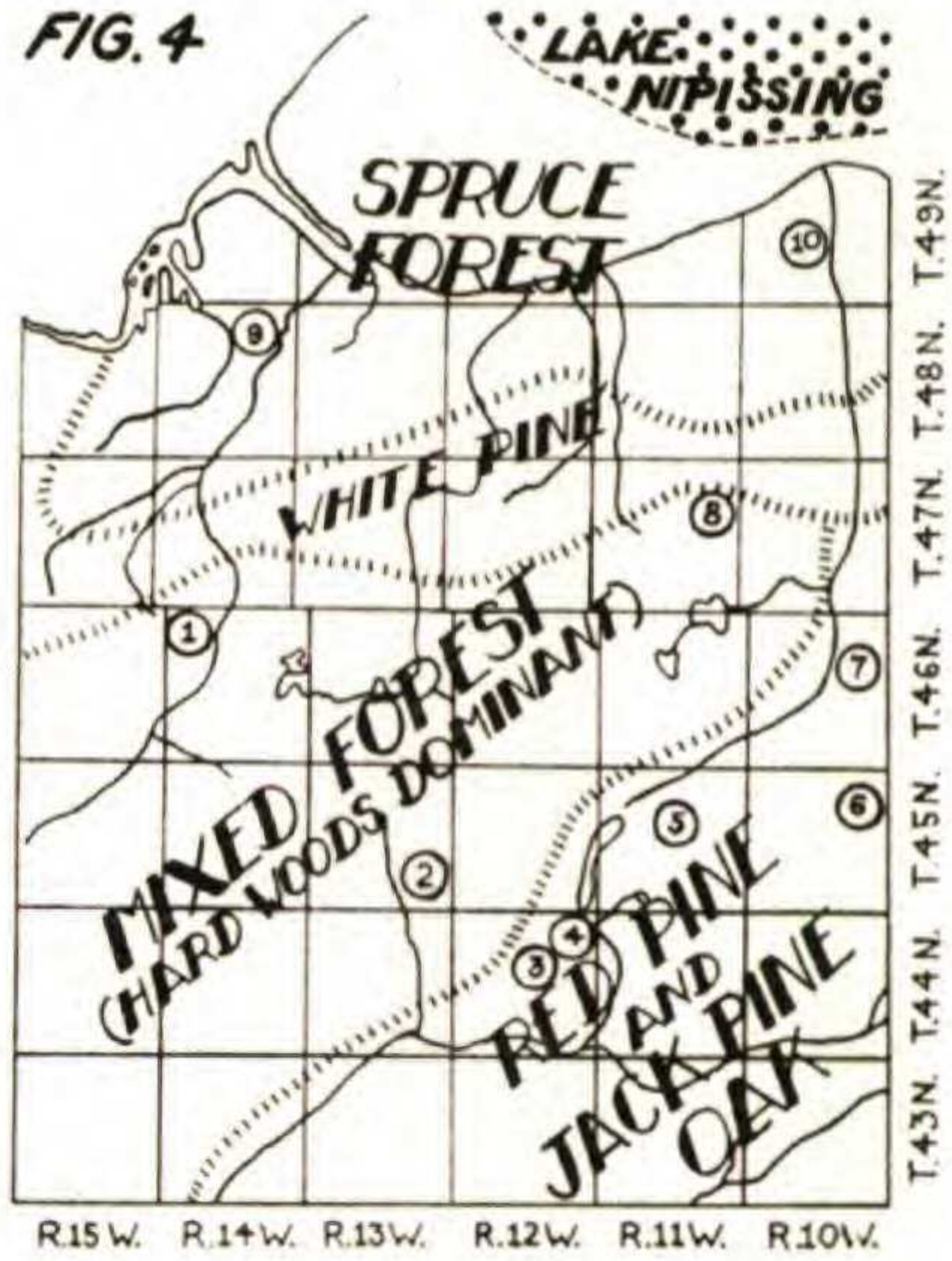


FIG. 5

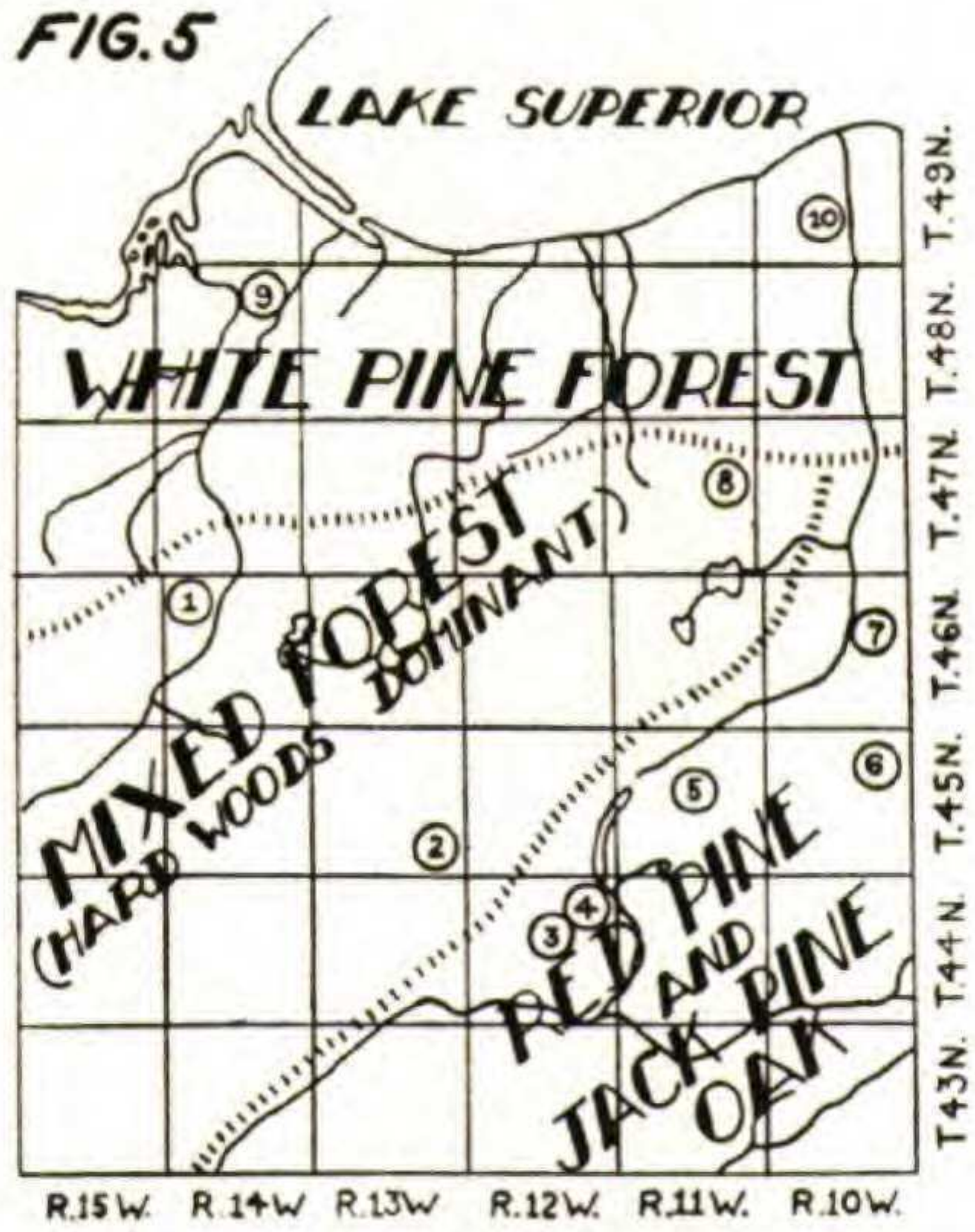


FIG. 6

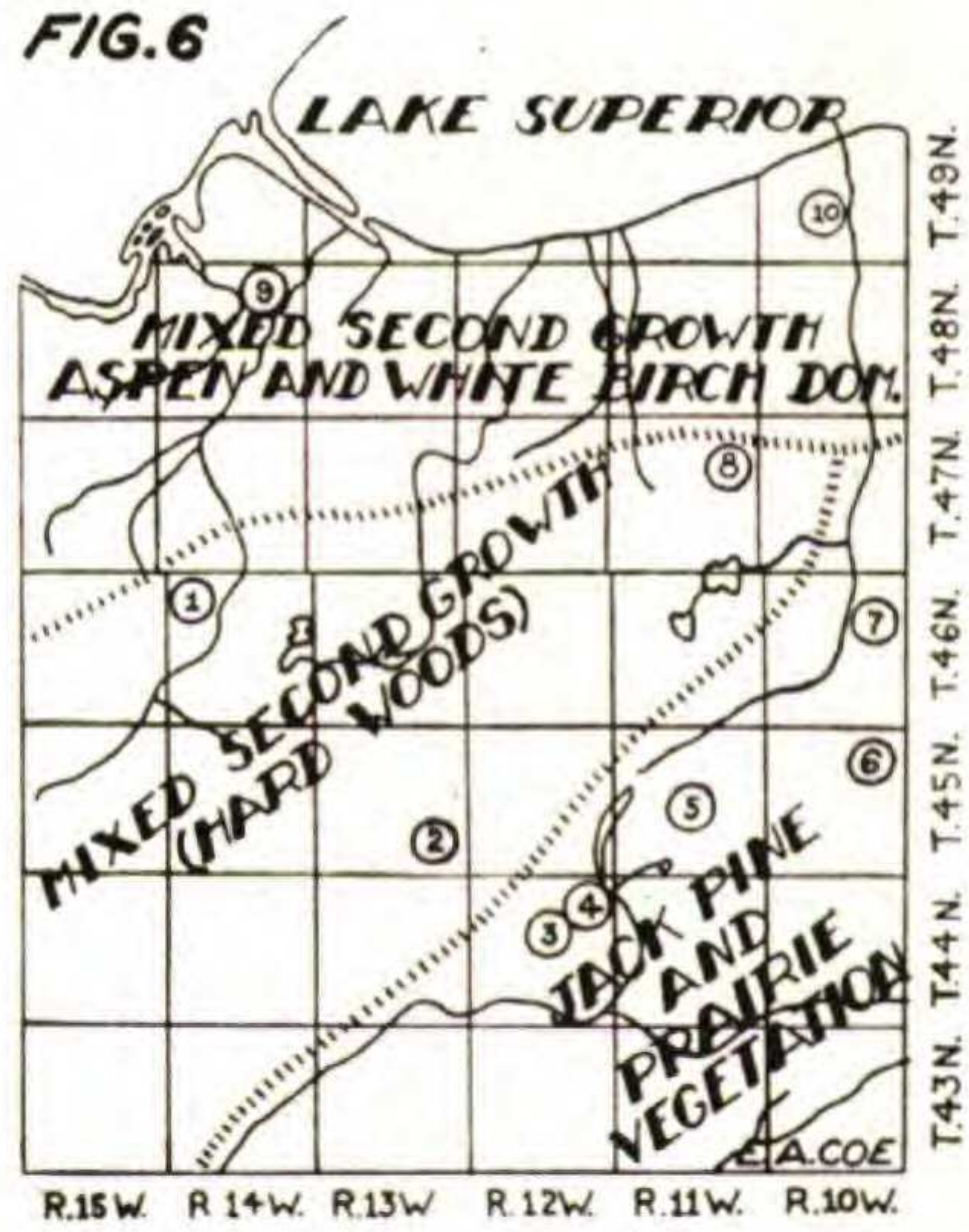


FIG. 1, Soil-belts of Douglas County, Wisconsin, and Locations of investigated Peat-deposits; 2, Forests of Douglas County at time of Glacial Lake Duluth; 3, Forests of Douglas County at time of Glacial Lake Algonquin; 4, Forests of Douglas County at time of Nipissing Great Lakes; 5, Forests of Douglas County in 1897, prior to extensive Lumbering Operations; 6, Forests of Douglas County at present time.

were not disturbed until examined by the writer. The gravels were deposited in the outlet river of Glacial Lake Duluth or possibly of the so-called "Glacial Lake Rouge" discussed by Martin. The two logs were parallel with one another and pointing in the general direction of the glacial river channel. The gravel overlying their resting place is very coarse and well washed. The hard-pan is of the same coarse material, but also has considerable sand mixed with it and the whole mass is cemented together with a ferruginous matrix. In digging out the logs it was necessary to dig about two feet below them. At that depth, masses of red clay typical of the Superior Lowland were encountered.

The logs were studied microscopically and found to be a species of spruce, possibly *Picea glauca* (Moench) Voss. They are in an excellent state of preservation and the growth-rings are easily counted. The larger log is six inches in diameter and has fifty-five growth-rings present, while the smaller log is approximately five inches in diameter and has forty-six growth-rings. These rings are of the same size as appear in logs of *P. glauca* today and they also show a reduction in width near the surface such as was observed in the logs of the Two Creeks Forest Bed (Wilson, '32).

During the maximum extension of the ice-lobe in the bed of Lake Superior and its gradual recession north of the Copper Range in Douglas County, there were glacial lakes present along its borders. These continued to grow in area and each survived long enough to allow the cutting of beaches.

While the Superior lobe was at its full extent there existed along the margin of the ice at the west end of the Lake Superior basin a glacial lake known as Glacial Lake St. Louis. It did not extend into Douglas County but occupied the central part of the St. Louis drainage basin in Minnesota. This lake drained down the present course of the St. Louis River to Scanlon, Minnesota, and from there southward to the Kettle River, thence to the St. Croix and Mississippi rivers.

As the ice front receded slightly there came into existence a small lake probably fifty square miles in area, in the upper part of the Nemadjii River basin. The well defined beaches and cuts made into morainic ridges indicate that this lake endured a considerable length of time.

On the eastern side of the county there appeared another small lake as the ice receded. This is known as Glacial Lake Brule, and it developed in the northern end of the Brule River valley. It covered an area of approximately twenty square miles.

At about this time, or earlier, in the valley of the St. Croix River there was forming a glacial lake due to an ice advance from the Kewatin center. The ice-front advanced across the Mississippi River between St. Paul and Clearwater, Minnesota, and reached Grantsburg, Wisconsin. This appears to have dammed the Mississippi and St. Croix Rivers and resulted in the formation of Glacial Lake Grantsburg. The presence of clays within the region further shows the existence of a body of glacial water. The extent of Lake Grantsburg is not agreed upon by geologists. By some, it is thought to have extended well into Douglas County (Hansell, '30), but by others the area of the glacial lake is thought to have been restricted to narrower limits in Burnett and Polk Counties.

With further recession of the ice in the Superior basin the several marginal lakes along the south range joined and fell to the common level of Glacial Lake Brule. The drainage of these lakes was south through the Brule-St. Croix rivers. Upon the formation of this larger body of water, Glacial Lake Duluth came into existence.

The outlet of Glacial Lake Duluth was also by way of the Brule and St. Croix rivers. This lake appears to have lasted a considerable period and became very extensive. This is suggested by the deepened channel and terraces of the outlet. Another evidence for its long duration is the well defined beaches upon its shores. The extent of this lake over Douglas County is shown in Figure 2. The lake must have stood nearly 700 feet higher than the present level of Lake Superior, and according to Hansell (l. c.) there is evidence of an even higher level.

When the ice in the Lake Superior basin melted away from the sides of the Huron Mountains and from the western part of the Upper Peninsula of Michigan, Glacial Lake Duluth began to drain into the Lake Michigan basin. There was a drop in the water level and gradually there came into existence the extensive Glacial Lake Algonquin. In the Superior basin the water level then stood about 350 feet above the present level of Lake Superior and the Brule-St. Croix outlet ceased to function. In Douglas County a new strip of land was exposed by this fall of the water level (Fig. 3). The ice in the Great Lakes basin continued to recede in a northeast direction and in so doing uncovered lower and lower outlets, which further lowered Glacial Lake Algonquin and brought into existence the Nipissing Great Lakes (FIG. 4). At the head of the Superior basin this shoreline is below the present one of Lake Superior. The Nipissing stage appears to have existed for a considerable period as is indicated by well marked beaches and extensive peat deposits submerged in Lake Superior. Martin (p. 463 l. c.) in discussing the duration of this lake states, "It seems possible that the present stage of Lake Superior has not yet existed as long as did the Nipissing Great Lakes." It is also true that the Nipissing beaches are broader and higher than those of lakes Duluth and Algonquin.

Lake Superior developed from the Nipissing Great Lakes largely as the result of the differential uplift of the region. This has resulted in the establishment of the St. Lawrence River outlet of the Great Lakes and, in Douglas County, the drowning of certain river valleys at the head of Lake Superior. Subsequent topographic modification in Douglas County has been restricted to the erosion of former lake and drift deposits by streams which flow across them and to the filling of small lakes with sedimentary materials forming swamps and boglands such as described above.

The Present Vegetation

The floral components of Douglas County are several but the most conspicuous is the Canadian. This flora in Douglas County is composed of such trees as *Pinus Banksiana, P. resinosa, P. Strobus, Picea glauca, P. mariana, Abies balsamea, Thuja occidentalis, Larix laricina, Betula papyrifera, B. lutea, Quercus borealis*, and *Acer saccharum*. It will be noted that the greatest number of these species are gymnosperms. The important shrubs of this flora are heaths and the following are the common species: *Andromeda glaucophylla, Gaylussacia baccata, Chamaedaphne calyculata, Vaccinium pennsylvanicum, Arctostaphylos Uva-ursi, Kalmia polifolia*, and *Ledum groenlandicum*. Other important shrubs are *Myrica Gale, M. asplenifolia, Betula pumila*, var. *glandulifera, Corylus americana, C. cornuta, Alnus crispa, A. incana, Acer spicatum, Dirca palustris*, several species of *Lonicera* and *Salix*, and numerous species in the complex genus *Rubus*. The species of the herbaceous flora are too numerous to list, but it contains in abundance such species as *Clintonia borealis, Coptis trifolia, Mitella nuda, Sarracenia purpurea, Chiogones hispidula* and *Moneses uniflora*.

The above species are present on the uplands or in the bogs and a number of them are important in the fossil records of Douglas County.

The second most important element in the flora of the county is the Alleghenian. To this belong such trees and shrubs as *Rhus typhina, Juglans cinerea, Ulmus americana, Tilia americana, Carpinus caroliniana, Prunus virginiana,* and several species of *Cornus.*

The third element is that of the Atlantic Coastal Plain. This according to McLaughlin ('32) is associated with the Glacial Great Lakes. The important species of this flora are *Xyris torta, Rynchospora capitellata, Eriocaulon septangulare, Vaccinium macrocarpon,* and *Echinochloa Walteri.*

The fourth member of the Douglas County flora is the prairie element. These are species that are all herbaceous and for the most part of technical taxonomic groups. They contain many grasses and composites as well as some legumes. In Douglas County this flora is confined to sandy soils.

The most recent floral member is the weed element that has invaded the region from Europe. These species are best developed upon cultivated or abandoned soil. *Ranunculus acris* and *Taraxacum officinale* especially have thrived, often to the extent of completely coloring the landscape.

The present vegetation is quite definitely divided into two belts, which to some extent closely follow the soils. The soil map of Douglas County (Fig. 1) shows several rather distinct regions, but the vegetation in these is generally distributed except in the *sand plain belt.* There is found at the edge of this belt a sharp transition and only species able to grow on light acid soils are to be found on the sand plain. This belt is locally known as the sand barrens, and the name quite graphically portrays the area. The vegetation upon the light sandy soils today is a remnant of a once extensive pine forest, and an invading prairie flora. Upon the *sand plain* many lakelets have developed into bog-land and upon these areas, in a few localities, are to be found bog-land associations of the same type as found in the other soil belts.

The *sandy loam, silt loam,* and *red clay* belts contain a more varied flora than the *sand plain,* and are more nearly alike in their components than one might expect. *Pinus Strobus, Acer saccharum,* and *Quercus borealis* were the dominant trees in the virgin forests. Over much of this area at the present time the two most important trees are *Populus tremuloides* and *Betula papyrifera.*

The condition of the forests in Douglas County near the end of the nineteenth century according to Roth ('98) and old residents was such that the northern one-third of the county (upon the red clay) was occupied almost wholly by *P. Strobus,* the middle one-third was a mixed hardwood and pine forest, and the southeastern part, except for that occupied by a silt loam in the extreme southeastern corner, was covered by *P. resinosa, P. Banksiana,* and *Quercus ellipsoidalis.*

Since that time the forests have been almost completely logged or burned over and today there remain only a few isolated areas of virgin timber. At the present time, according to Bordner and others (p. 18, '33), 79.5% of Douglas County is covered by forest land in various stages of development, 6.7% by bog and open swamp, 1.4% by water, and 1.9% by urban development.

Peat Deposits of Pro-Glacial Lake-Duluth-Age

It is stated above that Glacial Lake Duluth probably stood 700 feet above the present level of Lake Superior in Douglas County and drained by way of the Brule and St. Croix rivers. Therefore, the depressions located above this level should have come into existence with the recession of the ice sheet that controlled the elevation of the various glacial lakes in the Lake Superior Basin and they each must have developed independently from that early time. Those bogs numbered 1 and 2 in Fig. 2 are above the level of Glacial Lake Duluth and therefore represent the earliest depressions in which organic sediments could have collected. The existence of Lake Grantsburg in Douglas County is now generally discounted and the bogs numbered 3 to 6 inclusive are also of Pro-Lake-Duluth age.

It is impossible to state how soon after the formation of the depressions, in which each bog is located, organic sediments appeared, but there is evidence that indicates a very early date of deposition. Probably the best evidence is that found in bogs Nos. 3 and 4. These are formed in a pitted sand plain with ridges between them that indicates by the sharpness of the ridges that little subsequent modification has taken place in the topography since its formation. The bogs each cover an area of less than one acre and are surrounded on all sides by sand. In contrast to the sand walls the foundation of these bogs is blue clay, and downward, this gradually grades into Lake Superior red clay. Upon the blue clay no sand from the hillside was found, though a thorough search was made for it. Instead there is in both bogs a sharp contact of clay and peat. It seems reasonable to expect that small bodies of water standing so favorably located for the drifting or washing of sand from the hillsides would soon have a layer of sand over their floors, and the absence of this is strong evidence that plant life appeared in the ponds almost immediately after they were formed. In addition to the above evidence, seeds and rhizomes of *Nymphozanthus* are present in the very lowest levels of the moss peat. This is highly suggestive that a phanerogam vegetation persisted in the region at the edge of the ice sheet. This genus is to a large degree water-dispersed, and in order to reach the bogs at such an early time, it must have been very near.

Bog No. 1.—Bog No. 1 is located on the west side of State Trunk Highway 35, approximately five miles south of Pattison State Park. It covers an area of several acres in Sections 7 and 18, Township 46 North, Range 14 West. Three borings were made in this bog, and the deepest was 120 inches. The mineral soils beneath the peat were found to be a mixture of sand and clay. The depression in which the bog is developed is a kettle hole in ground moraine.

Through most of the profile the peat is of the black woody type, but below 85 inches of the deepest boring a more decomposed type was found. This latter is of the kind usually found in deep water of the present northern bog lakes and is definitely of sedimentary origin.

The living plants of the surface of the bog are predominantly *Picea mariana, Ledum groenlandicum, Chamaedaphne calyculata,* and *Vaccinium spp.* These plants cover a loose mat of *Sphagnum* and *Polytrichum.*

The tree flora of the surrounding upland is largely *Pinus Strobus, Betula papyrifera,* and *Populus tremuloides.* The other trees present in lesser abundance are *Acer rubrum, Quercus ellipsoidalis, Abies balsamea,* and *Pinus resinosa.* The important shrubs are *Alnus incana* and *Salix sp.* The herbaceous vegetation contains such species as *Cornus canadensis, Epigaea repens, Gaultheria procumbens, Gramineae spp.,* and several species of *Aster* and *Solidago.* The upland vegetation as a whole is just recovering from the effects of lumbering and recent severe burning. No indication was found of recent fire on the bog.

This peat deposit appears to be well above the highest elevation reached by the waters of Glacial Lake Duluth during the cutting of its well marked beach (Fig. 2) and should, therefore, present a record of the flora from the time of recession of the Mankato ice.

Percentages of Microfossils in Bog No. 1, Douglas County, Wisconsin

Species	Depth in Inches												
	120	*115*	*105*	*95*	*85*	*75*	*65*	*55*	*45*	*35*	*25*	*15*	*0*
Sphagnum	0	0	1	1.5	.5	.5	0	3	9	3.5	7.5	9	12
Polypodiaceae	0	0	0	0	0	0	0	0	.5	0	0	0	0
Lycopodium inundatum	.5	.5	0	0	0	0	0	0	0	0	0	0	0
L. annotinum	0	0	0	0	0	0	.5	0	0	0	0	.5	1
L. clavatum	0	.5	0	0	.5	0	.5	0	0	0	0	0	.5
L. obscurum	0	0	0	0	0	0	0	0	0	0	0	0	1
Pinus Strobus & P. resinosa	7	31	51.5	65.5	74	73	68	72.5	74.5	66.5	42	45.5	41
P. Banksiana	11	24	26	22.5	14.5	8.5	9.5	17.5	5.5	8.5	3	11.5	3.5
Picea	72	32.5	7.5	2	4	6.5	4	3.5	4	9	21.5	22	16.5
Larix	0	0	0	0	0	1	0	0	0	0	0	0	0
Abies	0	1.5	2	0	0	.5	0	0	.5	1	2.5	.5	1
Gramineae	3	2	3.5	0	1	0	0	0	0	0	0	0	0
Salix	0	0	0	0	0	0	1.5	0	0	0	1	0	.5
Betula	1.5	1	4	3.5	1	4	5	2	3	5.5	18.5	7.5	12
Alnus	0	1	.5	.5	0	.5	1.5	.5	0	1	1	.5	.5
Quercus	1	2.5	0	0	1	.5	2.5	0	0	2.5	2	0	1
Nymphaeaceae	1	1.5	1	0	0	0	0	0	0	0	0	0	0
Acer	1.5	1	1	1.5	1.5	2.5	1.5	0	.5	1	0	1	.5
Tilia	0	0	0	0	0	0	0	0	.5	.5	0	0	0
Ericaceae	0	.5	0	.5	0	0	0	0	0	0	0	1	7.5
Chamaedaphne	0	0	0	.5	0	0	0	0	0	.5	0	0	0
Compositae	1.5	.5	2	2	2	2.5	5.5	1	2	.5	1	1	1.5

Bog No. 2	*41*	*38*	*36*	*31*	*26*	*18*	*14*	*9*	*6*	*4*	*0*
Sphagnum	0	0	0	4	1	.5	20	7.5	.5	12	7
Lycopodium annotinum	0	0	0	0	0	0	0	0	0	0	.5
L. clavatum	0	0	0	0	0	0	0	.5	0	0	.5
Pinus Strobus & P. resinosa	5	6	16	6	12	15.5	12	10	19.5	15	32
P. Banksiana	0	0	0	0	0	0	0	0	0	1	1
Picea	94	90	74	86	84	64	57	57	58.5	48	38
Abies	0	0	10	0	0	.5	1	3.5	1	4	2

Depth in Inches

Bog No. 2 (Continued)	41	38	36	31	26	18	14	9	6	4	0
Gramineae	0	0	0	0	0	2	0	0	0	0	.5
Salix	0	0	0	0	.5	1	1	0	0	0	.5
Betula	0	2	0	2	.5	6	5	18	15	11	8
Alnus	0	0	0	0	.5	3	.5	1.5	1.5	1	1
Quercus	0	0	0	0	.5	2	1.5	1.5	2	2	1
Acer	0	2	0	0	.5	1	.5	0	0	1	0
Ostrya	0	0	0	0	0	.5	0	0	0	0	0
Ericaceae	0	0	0	0	0	0	0	0	1.5	1	2
Compositae	1	0	0	2	.5	4	1.5	.5	.5	4	6

Bog No. 3	60	57	54	50	44	37	33	27	22	12	8	0
Sphagnum	0	0	0	0	4	3	26.5	19	40	14	27.5	3.5
Lycopodium annotinum	0	0	0	0	0	0	0	0	.5	0	0	0
L. clavatum	0	0	0	0	.5	0	0	18	16	6.5	5	0
Pinus Strobus & P. resinosa	0	0	10	10	20.5	18	13.5	1.5	3	2	.5	23
P. Banksiana	22	10	30	16	3	3.5	6.5	39.5	34	39	59	27.5
Picea	74	86	56	64	64.5	64.5	30.5	0	0	1.5	2	30.5
Abies	2	4	2	3	1	0	.5	1	0	0	0	.5
Salix	0	0	2	3	.5	.5	2.5	14.5	0	29	3.5	.5
Betula	2	0	0	2	2	2	5	1	.5	.5	.5	5
Alnus	0	0	0	0	0	1	1.5	.5	0	2.5	0	.5
Quercus	0	0	0	0	.5	3	1.5	0	0	0	0	2
Tilia	0	0	0	0	0	0	0	.5	0	0	0	0
Ericaceae	0	0	0	0	5	2	10	3	4.5	2.5	2	1.5
Chamaedaphne	0	0	0	0	0	0	0	0	0	0	0	.5
Compositae	0	0	0	2	1.5	2.5	2	1.5	1.5	2.5	0	5

Bog. No. 4	81	72	63	54	45	36	27	18	9	4	0
Sphagnum	6	2	1	2	13	14	51.5	13	11	19	13.5
Lycopodium annotinum	0	0	0	0	0	0	0	0	0	0	.5
L. clavatum	0	0	0	0	0	0	0	0	.5	0	0
Pinus Strobus & P. resinosa	0	14	37	44	55	33	10.5	25.5	30	20	23.5
P. Banksiana	24	56	4	38	10	9.5	7	4.5	6.5	6.5	9.5
Picea	70	28	48	11.5	15.5	22	24	50.5	45	45	42

Depth in Inches

Bog No. 4 (Continued)	*81*	*72*	*63*	*54*	*45*	*36*	*27*	*18*	*9*	*4*	*0*
Abies	0	0	0	0	0	0	0	1	0	.5	.5
Salix	0	0	1	0	.5	4	0	0	.5	0	1
Betula	0	0	5	1	2	1.5	0	3.5	5	4.5	5
Alnus	0	0	0	1	.5	.5	.5	0	0	.5	1
Quercus	0	0	4	0	1	2.5	.5	1	1	.5	1
Tilia	0	0	0	0	0	0	0	0	0	0	.5
Ericaceae	0	0	0	1	2	8.5	4.5	1	.5	3	.5
Compositae	0	0	0	1.5	.5	4.5	1.5	0	0	.5	1.5

Bog No. 5	*85*	*75*	*65*	*55*	*45*	*35*	*25*	*15*	*5*	*0*
Sphagnum	0	1.5	1	0	1	2	2.5	2.5	3	22
Polypodiaceae	0	0	0	0	0	0	.5	1	4	0
Lycopodium annotinum	0	0	0	0	0	0	0	0	1	0
L. clavatum	0	0	0	0	0	0	0	0	0	2
Pinus Strobus & P. resinosa	0	9.5	11	16	18.5	30	29	31	33	14
P. Banksiana	0	52.5	61	15	3.5	22	30	29	18	34
Picea	100	17.5	9.5	17.5	41	25.5	19	20	17	0
Abies	0	0	.5	3.5	10	.5	.5	1	2	0
Gramineae	0	9.5	9.5	45	23.5	9	10	0	0	0
Salix	0	1	0	.5	.5	0	1	2.5	1	0
Betula	0	4	2	0	.5	5	3.5	8	11	18
Alnus	0	0	2	0	.5	.5	1	2	2	0
Quercus	0	0	0	0	0	1	.5	.5	0	0
Acer	0	2	1	.5	0	1	0	0	0	0
Ericaceae	0	0	0	0	0	0	0	.5	3	0
Chamaedaphne	0	0	0	0	0	1.5	0	0	4	0
Compositae	0	2.5	2.5	2	1	2	2.5	2	1	10

Bog No. 6	*135*	*125*	*115*	*105*	*95*	*75*	*65*	*55*	*45*	*35*	*25*	*15*	*5*	*0*
Sphagnum	0	0	0	0	0	0	0	.5	0	0	.5	0	0	0
Polypodiaceae	0	0	0	0	0	0	0	0	0	0	0	.5	.5	0
Botrychium ternatum	0	0	0	0	0	0	0	0	0	0	.5	0	0	0
Lycopodium annotinum	0	0	0	0	0	0	0	0	0	0	.5	0	0	0
L. clavatum	0	0	0	0	0	0	0	0	0	.5	.5	0	0	0

Depth in Inches

Bog No. 6 (Continued)	135	125	115	105	95	75	65	55	45	35	25	15	5	0
Pinus Strobus & P. resinosa	7	36	50	48	51	46	46	47	50	47.5	42.5	44	51	30
P. Banksiana	36	56	26	38	32	37	40	39	25	28	20	30	29	42
Picea	57	6	18	10	10.5	12	3.5	7.5	14	14	28	20	12	12
Abies	0	0	0	2	0	1	0	0	1	0	.5	0	1	2
Typha	0	0	0	0	0	0	0	.5	0	0	0	0	0	0
Gramineae	0	0	0	0	3.5	0	6	0	0	0	0	0	0	0
Betula	0	2	4	0	2	2	1	.5	2.5	4	2.5	3.5	3	2
Alnus	0	0	0	0	0	.5	.5	0	0	1	0	0	.5	2
Quercus	0	0	2	0	0	.5	2	1	4	3	2	1	1	0
Acer	0	0	0	0	0	0	0	2	1	1	1	0	0	0
Compositae	0	0	0	2	1	1	1	2	2.5	1	1.5	1	2	10

Bog No. 7	33	32	26	24	20	17	15	12	11	8	4	0
Sphagnum	0	0	2	2	0	2	24	16	6	2	9.5	2
Polypodiaceae	0	0	0	10	0	0	0	0	4	0	0	.5
Lycopodium annotinum	0	0	0	0	0	2	0	0	0	0	0	0
L. clavatum	0	0	0	0	0	6	0	2	0	0	0	0
Pinus Strobus & P. resinosa	36	18	38	24	38	18	28	24	20	18	12.5	32
P. Banksiana	14	4	6	28	6	14	14	20	16	16	3	2.5
Picea	46	28	50	36	42	46	30	32	50	56	64	19
Larix	0	0	0	0	0	0	0	0	0	0	0	.5
Abies	0	2	2	0	0	8	0	6	0	2	1.5	2.5
Gramineae	0	0	0	0	0	0	0	0	0	0	0	1.5
Salix	0	0	0	0	0	0	2	0	0	0	1	1
Betula	2	2	0	0	10	0	0	0	2	4	2	1
Alnus	2	46	0	0	0	4	2	0	0	0	1	8.5
Quercus	0	0	0	0	2	0	0	0	0	0	1	1
Ericaceae	0	0	0	0	0	0	0	0	0	0	2	.5
Compositae	0	0	2	0	2	0	0	0	2	2	2.5	27.5

Bog No. 8	Depth in Inches 54	53	50	47	43	39	36	33	28	22	16	11	7	3	0
Sphagnum	0	0	0	0	.5	0	.5	1	0	0	3	12	6	6	3
Polypodiaceae	0	0	0	0	0	0	0	0	0	.5	0	0	0	0	1
Lycopodium lucidulum	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
L. annotinum	0	0	0	0	.5	0	0	0	0	0	0	0	0	0	0
L. clavatum	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
Selaginella selaginoides	0	0	0	2	4.5	14	0	0	0	0	0	0	0	0	0
Pinus Strobus & P. resinosa	0	0	0	0	5.5	11	20	21	29.5	18	18	7	12	24	19
P. Banksiana	0	0	0	0	0	0	8	11	23.5	5	4	4	8	10	11
Picea	100	100	100	98	84	67	62	50	27	24	57	55	46	32	11
Abies	0	0	0	0	3	3	3	12	16	8	7	4	8	9	4
Gramineae	0	0	0	0	2	4	2	2	0	6	4	11	7	4	25
Cyperaceae	0	0	0	0	0	0	0	.5	0	36	0	0	3	0	0
Salix	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0
Betula	0	0	0	0	0	0	1.5	1.5	1.5	0	4	4	3	13	5
Alnus	0	0	0	0	0	0	.5	0	1	0	1	0	3	0	3
Quercus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Acer	0	0	0	0	0	0	.5	.5	0	0	1	0	0	0	0
Ericaceae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Compositae	0	0	0	0	0	0	2	.5	1.5	1.5	0	2	1	1	16

Bog No. 2.—This bog is located on the north side of County Highway N, in Section 26, Township 45 North, Range 13 West.

It covers an area of approximately one quarter-acre and its maximum depth is forty-one inches. The mineral soil upon which the deposit has developed is a sandy blue clay and the soil of the surrounding area is a heavy sand-loam with many boulders dispersed through it. These soils constitute part of the Kerrick Morainic System mapped by Leverett (p. 23, '28). The basin in which Bog Number 2 has developed is a kettle hole in this moraine.

The peat below 31 inches appears to be of a truly limnic type while above that depth it contains wood and *Sphagnum* which indicates that the pond stage had been passed.

The plants on the bog at the present time are *Larix laricina* (dominant), *Picea mariana, Ledum groenlandicum, Chamaedaphne calyculata,* and several species of *Vaccinium* and *Carex*. The mat upon which these plants are growing is composed of *Sphagnum sp.* and *Polytrichum strictum*. The trees do not form a dense cover, for they are all approximately fifteen feet apart.

The upland flora is of the hardwood type with *Fraxinus pennsylvanica* var. *lanceolata, Ulmus americana,* and *Tilia americana* dominant. There also occur a few trees of *Pinus Strobus*, and *Picea glauca* in the area adjacent to the bog.

Like the previous deposit this one should also record the vegetation from its earliest appearance in the region.

Bog No. 3.—Bog No. 3 is approximately two miles south of the village of Solon Springs in Section 1, Township 44 North, Range 12 West.

The area of the deposit is slightly less than one acre. Six test pits were dug into it and a detailed cross-section of the deposit was studied. The deepest test pit was sixty inches to the contact with blue clay. Red lacustrine clay underlies the blue.

The whole deposit is developed in a saucer-like depression of lacustrine clay, the origin of which is not clear, but it appears to extend under the sand-hills that surround the bog. The depression is obviously a glacial kettle and the sand-hills which surround this and the other bogs of the vicinity are features of pitted outwash topography. The upland soil is a light cross-bedded sand with lenses of fine gravel interspersed.

In the deepest test pit there was found twenty-four inches of blue clay overlying red clay of the same lithology. Overlying the blue clay in sharp contrast a thirteen inch layer of *Drepanocladus* and *Nymphozanthus* peat was found. This peat is composed of remarkably well preserved moss plants and rhizomes and seeds of *Nymphozanthus*. The sharp contact of the peat and clay, and lack of sand particles between the two, have been noted above as suggesting a very early colonization of the area by plant life. The mosses, when examined by Mr. L. S. Cheney, were found to be *Drepanocladus revolvens* and *D. Wilsoni*. These are aquatic forms which today have an Arctic and Canadian distribution.

Near the top of the brown moss peat there occurred a three inch layer of transitional material which contained fragments of *Drepanocladus* moss and finely divided limnic sediment. This peat type gave way above to a black and somewhat heterogeneous fibrous material. The upper stratum was 27 inches thick and in this material at a depth of 32 inches from the surface a thin charcoal layer was found. This indicates a burning of the bog surface, probably due to a forest fire in the region at a very early date in the post-glacial history of the region. The black fibrous peat is overlain by a loose mat of *Sphagnum* moss. It forms a cover that is nearly 17 inches thick over most of the bog. At the contact of the *Sphagnum* mat and the black peat, another charcoal layer was found. This layer is the result of fires that severely burned the bog cover and the surrounding upland in 1918.

The bog cover at the present time is almost entirely *Chamaedaphne calyculata* except near the edges where it is replaced to some extent by several species of *Carex*. Buried in the *Sphagnum* mat are to be found many stumps of *Picea mariana* which were burnt nearly to the level of their roots. Around the outer edge of the bog on the south side several species of *Salix* have become established and have formed a dense cover.

The upland flora has also suffered great destruction from the fire of 1918. There was previous to that time a moderate second-growth cover of *Pinus resinosa* and *P. Banksiana* but the forest fire which swept the area has not only almost completely destroyed this cover but also has burned off the upper humus layer of the soil.

Bog No. 4.—The location of this bog is a few hundred yards north of Bog Nunber 3, in Section 1, Township 44 North, Range 12 West.

The area of the bog is slightly more than one-fourth acre and the greatest depth found was eighty-one inches. The formation of this deposit is identical with that of Bog No. 3. The basin soil is a blue lacustrine clay underlain by red clay of the same origin.

The peat was found to be in sharp contact with the blue clay and no sand was observed as occurring between the two deposits. The aquatic moss which makes up the lower peat stratum is *Calliergon trifarium* and is in the same perfect state of preservation as the mosses in Bog 3. This layer in the center of the bog was found to be eighteen inches thick and at the top to undergo a transition into a black limnic peat. The limnic peat also forms a layer which is nearly eighteen inches thick, and above that the peaty material is black and fibrous in nature. Much wood and moss tissues were found throughout.

The mat covering the bog is composed of several species of *Sphagnum* and of *Polytrichum strictum*. The plants occurring on this mat are *Chamaedaphne calyculata*, *Ledum groenlandicum*, and a few small trees of *Picea mariana*.

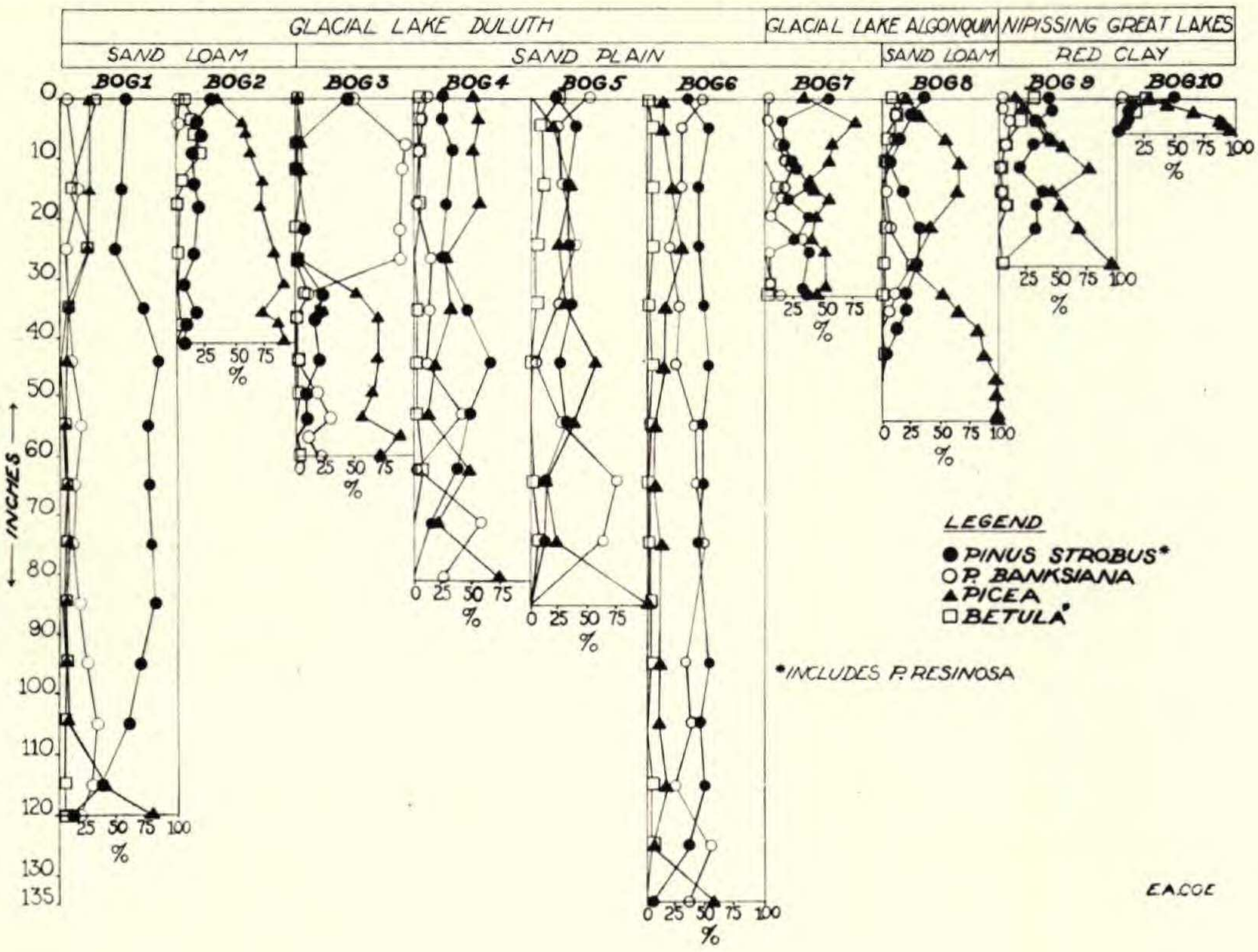
The upland flora is much more dense than it is around Bog No. 3. There are many trees of *Pinus resinosa*, *P. Banksiana*, *Betula papyrifera*, *Populus tremuloides*, and a few scattered trees of *Abies balsamea* and *Tilia americana* on the hillsides. The shrubs are *Salix sp.*, *Alnus incana*, *Myrica asplenifolia*, and *Rosa sp.* The herbaceous plants are *Aster sp.*, *Liatris sp.*, *Solidago sp.*, *Rubus sp.*, and *Andropogon furcatus*.

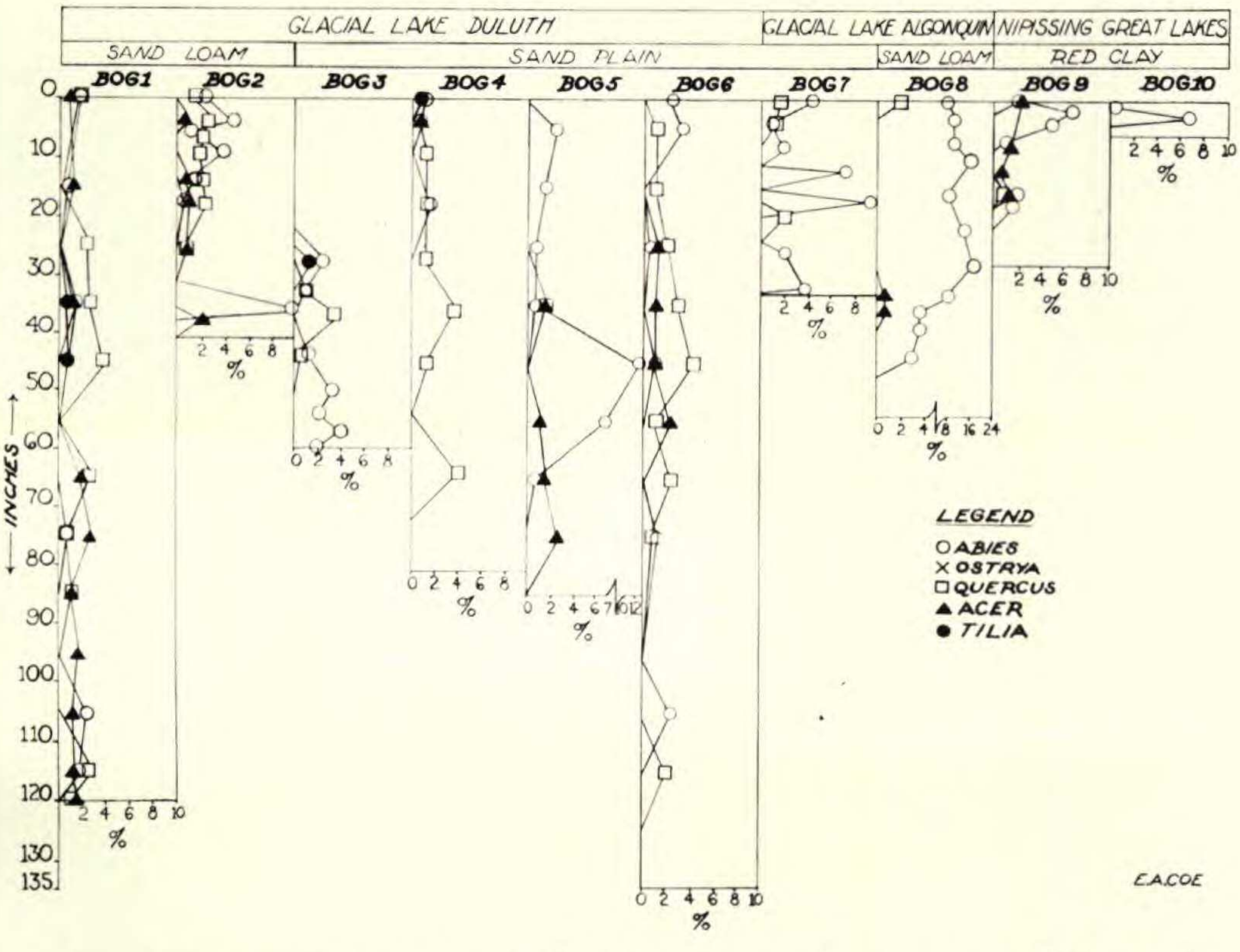
Bog No. 5.—On the north side of County Highway N. in Section 21, Township 45 North, Range 11 West.

The area of this deposit is about one-quarter of an acre. Three test-pits were studied and the deepest was found to be eighty-four inches. The mineral soil underlying the peat is a silty sand. It was mixed with considerable organic material to a depth of one inch below the contact and was found to contain microfossils in comparative abundance. The topography of the area about Bog No. 5 is developed in a pitted outwash plain.

The lowest forty inches of peat in this deposit appears to be entirely of the limnic type and through a transition layer nearly ten inches thick it grades into a woody *Sphagnum* moss peat. This latter type is found upward to within eleven inches of the surface in the middle of the bog and there the peat is a compacted layer of *Sphagnum*.

This bog is oval in shape and there are three zones of vegetation concentrically arranged on its surface. The center zone is covered





FIGS. 7 (above) and 8 (below), Graphs showing Percentages of Tree-pollen in the Douglas County, Wisconsin, Peat-deposits. Percentages computed from TREE-POLLENS only.

by a thick mat of *Sphagnum spp.* and *Polytrichum strictum.* On this there is growing a small clump of *Chamaedaphne calyculata.* The zone surrounding the *Sphagnum* is one of *Carex sp.* and contains a number of small trees of *Pinus Banksiana,* and *Populus tremuloides.* The third and outer zone is made up of a dominant cover of *Rubus sp.* and a number of small trees of *Populus tremuloides.*

The upland flora has suffered greatly from a recent forest fire, but no evidence of this fire was found on the bog. The vegetation of the surrounding sandy hillsides is meager and is composed largely of small trees of *Pinus Banksiana, P. resinosa,* and *Quercus ellipsoidalis.* The herbaceous vegetation is largely of a prairie character with *Aster sp., Solidago sp.,* and *Liatris sp.* dominating.

Bog No. 6.—Bog No. 6 is located on the west side of County Highway H in Section 13, Township 45 North, Range 10 West. It lies in a kettle-hole between Murray and Sand Lakes and during normal years it contains a little water over a mat of *Carex* peat. In 1933 this deposit was studied and during that year and the succeeding, no water stood in the basin of the depression.

The area of the whole deposit is probably less than one-sixth of an acre. The deepest boring was made near the center of the bog, and sand was encountered at one hundred and thirty-five inches below the surface.

The depression in which Bog Number 6 has developed, as well as those in which are located the nearby lakes, are kettle-holes left by ice-blocks in a pitted outwash plain. The upland soils are outwash sands and gravels.

The whole profile of peat in this bog must be considered as limnic in origin except possibly for the *Carex* tissues which accumulate on the surface of the deposit during dry periods. During the last few years this has been the only source of building material that has accumulated in the depression. It is quite possible that in the development of this deposit we have now a transition type of peat in the process of formation. What may follow is a matter of conjecture based upon observations of other profiles in the region. It is quite possible that a *Carex* peat will succeed the peat now forming and as the deposit matures, this will be succeeded in turn by a *Sphagnum* and *Polytrichum* moss cover. Another trend is also possible if the *Carex* peat becomes modified by weathering agents. This alternative is the invasion of the bog area by deciduous trees and shrubs.

The bog cover when studied was composed of a number of species of sedges and species of *Solidago* and *Eupatorium*. Around the bog are shrubs of *Salix spp.*, and *Alnus incana*. The flora on the surrounding upland is a thin second growth forest chiefly composed of *Pinus resinosa*, *P. Banksiana*, *Quercus ellipsoidalis*, and *Betula papyrifera*.

PEAT DEPOSITS OF PRO-GLACIAL LAKE ALGONQUIN AGE

With the uncovering of a lower outlet for the waters held between the front of the retreating ice in the Lake Superior Basin and the hills which surround the basin, the water level in Lake Duluth dropped to that occupied by Lake Algonquin. As a result of this drop in water level there was exposed a narrow strip of land upon which vegetation could establish itself (FIG. 3).

The general gradient of the exposed strip of land is comparatively steep and consequent drainage has been so vigorous that it has cut back into the headland and has perfected the run off to a marked degree. This has resulted in the leaving of very few undrained depressions in which organic sediments could accumulate. This fact and the narrowness of the newly exposed land area are the two factors which seem to explain the scarcity of peat deposits which began their formation with the establishment of the best known level of Lake Algonquin in Douglas County.

BOG NO. 7.—Bog Number 7 is located on the east side of County Highway H in Section 3 of Township 46 North and Range 10 West. It was formed in an undrained depression on the highest terrace of the Brule River.

The area of the entire deposit is less than one-half acre and the deepest test pit was thirty-three inches. At that depth a blue clay was encountered. The soils of the surrounding area are sandy and contain some river-gravels and large boulders.

This deposit began its development with the fall of the water in Lake Duluth and the disuse of the highest terrace in the Brule River valley. Whether the cutting of the next lower terrace marked the end of Lake Duluth and the beginning of Lake Algonquin is not known, but the time interval between the use of the highest terrace and the cutting of the next lower must have been considerable, and if the assumption that this deposit is of Pro-Algonquin age is incorrect, it is at least much younger than those deposits already discussed. It is stated above that Lake Duluth drained by way of the Brule and

St. Croix rivers and that this stage of the Glacial Great Lakes persisted for a rather long period of time. It is assumed that vegetation spread northward very shortly after the region was uncovered by the Mankato ice. If that is true the outlet river of Lake Duluth was bordered by forests long before Bog Number 7 emerged from the bed of the glacial lake outlet. The distance from the bog-deposit to the ancient river-bank is less than two hundred yards, therefore it seems reasonable to suppose that in the earliest sediments that accumulated in the depression will be found microfossils from the vegetation of the hillside. The presence of these will then give the basal deposit nearly the same spectrum as is found at higher levels in other deposits not similarly situated.

In this deposit three layers of charcoal were found. These were at 17, 12, and 9 inches, respectively, below the surface in the deepest test pit. The lowest seven inches of peat is decidedly of an aquatic type and above that level the peat contains wood and some moss tissues. The top cover is a dry *Sphagnum* with sedges, *Ledum groenlandicum*, *Chamadaphne calyculata*, *Alnus incana*, *Betula pumila*, *Salix sp.*, *Larix laricina*, *Abies balsamea*, and *Picea mariana*. These plants form a dense tangle over the bog area.

The upland flora north of the bog contains many large trees of *Pinus resinosa*, and *P. Strobus*. Other trees of the area are *Populus grandidentata*, *Betula papyrifera*, *Quercus ellipsoidalis*, and *Pinus Banksiana*.

Bog No. 8.—This deposit is located on the east side of County Highway E approximately two and one-half miles north of the village of Lake Nebagamon in Section 13 of Township 47 North, and Range 11 West.

According to the map prepared by Hansell (l. c.) this bog is located between two islands that existed in Glacial Lake Duluth. The map prepared by Leverett ('28) does not show the presence of these islands. Instead he indicates that there was a slight invagination in the coast line of Lake Duluth, and though this does not definitely extend over the entire area of the bog, the probability of that extension is great.

The full extent of the bog was not investigated, but it probably covers more than forty acres. In the deeper test pit, contact with blue clay was found at fifty-four inches below the surface. The lowest eighteen inches of peat are of limnic origin and above that level a black, woody peat is present.

The present bog contains little *Sphagnum* and the mesophytic cover suggests that the peat is undergoing surface modification. This contains such plants as *Osmunda regalis, Thuja occidentalis, Abies balsamea, Betula lutea, Fraxinus pennsylvanica,* var. *lanceolata, Alnus incana, Nemopanthus mucronata, Cornus stolonifera,* and species of *Rubus, Aster, Solidago,* and *Gramineae.*

The upland flora is composed of a young, mixed, second growth forest in which *Populus tremuloides, Betula papyrifera, Pinus Strobus, P. resinosa, Acer saccharum, Quercus ellipsoidalis,* and *Prunus pennsylvanica* are important members.

Peat Deposits of Pro-Nipissing Great Lakes Age

With the gradual northeastward recession of the ice mass in the present Lake Superior basin a continuous drop in the level of Glacial Lake Algonquin resulted. Finally an outlet was established via the Ottawa River and the water fell to the level known as the Nipissing Great Lakes. At the west end of the Lake Superior basin this level was below that of the present lake, and part of this area has since been submerged as the result of differential uplift in the region of Lake Superior. Upon the newly exposed area forests soon became established. This is indicated by the presence of buried peat-beds near the Apostle Islands, Bayfield County, Wisconsin (Wilson, '35) and off Minnesota and Wisconsin Points at the west end of Lake Superior. The age of the peats is considered to be the same as the One Outlet Stage of the Nipissing Great Lakes. An examination of peat from the Apostle Islands Region shows that is was formed in association with a complex flora and the material that was recovered for study did not include basal strata containing the usual pioneer flora of *Picea.*

The belt of Pro-Lake Nipissing land at present exposed above Lake Superior probably ranges from twelve to thirty miles wide (Fig. 4). This land area has a gentle slope toward the lake and may be justly described as a lake-plain. Upon the plain in a few undrained irregularities peat soils have accumulated. Two of these deposits have been examined in detail.

Bog No. 9.—This deposit is located on the west side of 58th Street and Hammond Avenue in South Superior. It is in Section 2 of Township 48 North and Range 14 West. The area of Bog Number 9 is about one acre in extent.

The basin in which the peat has accumulated is an undrained irregularity in the lake-plain. The origin of the depression may be a meander-channel of the Nemadjii River that was abandoned very early.

Percentages of Microfossils in Bog No. 9, Douglas County, Wisconsin

Species	Depth in Inches									
	28	*22*	*18*	*16*	*12*	*8*	*7*	*4*	*2*	*0*
Sphagnum	7	2	38	17.5	30	55	67	75	21	2
Lycopodium annotinum	0	0	0	1	0	0	0	0	0	1
L. clavatum	1	0	0	0	0	0	0	0	0	0
Pinus Strobus & P. resinosa	0	30	17	29	13	13	13.5	6	21	21
P. Banksiana	0	0	4	3.5	.5	3	1.5	2	1	1
Picea	79	68	30	38	54	24	14	7	10	7
Abies	0	0	1	1.5	0	0	.5	1	3	1
Gramineae	12	0	.5	0	0	0	0	0	0	5
Salix	0	0	.5	.5	0	.5	.5	0	0	0
Betula	1	0	3	3	.5	2.5	2.5	4	9	14
Alnus	0	0	1	2	0	0	0	3	4	2
Quercus	0	0	0	.5	0	0	0	0	0	0
Acer	0	0	0	1	.5	0	0	0	0	1
Ericacea	0	0	3	1.5	1.5	1	.5	1	5	6
Compositae	0	0	2	1	0	1	0	1	26	39

Percentages of Microfossils in Bog No. 10, Douglas County, Wisconsin

Species	Depth in Inches					
	6	*5.5*	*4*	*2.5*	*1.5*	*0*
Sphagnum	2	0	2	0	2	0
Polypodiaceae	0	0	0	0	2	0
Lycopodium annotinum	10	20	6	6	4	2
L. clavatum	1	0	2	2	4	4
Pinus Strobus & P. resinosa	1	7	8	6	8	24
P. Banksiana	1	0	0	0	0	2
Picea	85	72	80	36	26	8
Abies	0	0	0	4	16	0
Gramineae	0	0	0	0	2	0
Salix	0	1	0	2	0	0
Betula	0	0	0	10	10	12
Alnus	0	0	0	28	10	18
Compositae	0	0	2	6	16	30

Three test-pits were studied and the deepest was found to contain twenty-eight inches of peat. The peat was found to be in contact with blue clay, and the lower six inches appear to be limnic in origin. The peat above that level is distinctly of a woody type which contains much *Sphagnum* moss tissues.

This bog is fast being destroyed by burning and civic improvements, but when studied in 1933 it was covered by a dry *Sphagnum* mat upon which a few small trees of *Picea mariana* grew and in addition the following heaths were abundant: *Ledum groenlandicum, Chamaedaphne calyculata,* and *Vaccinium Vitis-Idea,* var. *minor.* The occurrence of the last species is of special interest because at the present time this is one of the two known stations for it in Wisconsin. It is more abundant on the north shore of Lake Superior. The persistence of this subarctic plant on Bog Number 9 is an argument for the bog's continuous development from early Lake Nipissing time.

The upland vegetation is a sparse second growth cover of *Alnus incana, Betula papyrifera, Abies balsamea, Salix sp., Pinus Strobus* and *Populus tremuliodes.*

Bog No. 10.—Bog No. 10 is located on the west side of a township road that reaches the mouth of the Brule River from U. S. Highway 13. The bog is in Section 16 of Township 49 North, and Range 10 West.

Like the preceding deposit this one is in an undrained depression of the lake-plain. The area of the deposit is not more than five hundred square feet and its maximum depth is only six inches. Below the peat the soil is a heavy pink clay.

When the peat materials were collected there was some doubt concerning the possible use of this deposit, but upon examination the same type of spectrum as found in other deposits was recognizable though much compressed. No oxidation of the peat was found. The nature of the peat varies considerably through the shallow profiles. The surface peat is composed of a loose mat of *Sphagnum* moss; below this and to a depth of two and one-half inches the peat is fibrous and somewhat woody; the next underlying peat-type is completely homogeneous and extends downward to the five-inch level, where the peat becomes a mixture of mineral and organic sediment one inch thick.

The flora of the bog and surrounding area is such as is found growing on clay soils in the Lake Superior Region. The dominant trees are *Abies balsamea, Picea mariana, Betula papyrifera,* and *Populus tremuloides.* The dominant shrub is *Alnus incana.* The herbaceous flora is composed of *Cornus canadensis, Clintonia borealis, Aralia nudicaulis,* several species of *Aster, Petasites sp., Lycopodium annotinum,* and *L. obscurum.*

Comparative Studies of Fossil Spectra in Northwestern Wisconsin

It is generally conceded that under normal sedimentation and peat development a profile study of the microfossils in a bog deposit will give an accurate record of the preservable organic succession. That this record begins with the immediate formation of the basin in which sediments may accumulate is not reasonable to expect, but that the record began very early after the basins were formed in Douglas County, Wisconsin, is strongly suggested by the evidence already discussed. The bogs which present this evidence are among the oldest in the region and it may be logically assumed that the younger bogs likewise record the earliest sediments containing microfossils in their respective areas since it has been shown that vegetation was in the region during Pro-Lake Duluth time. An examination of the lowest peat horizon always reveals a predominance of fossil *Picea* pollen. The species of this genus are considered to be pioneers and their appearance in Douglas County in the basal levels of all peat deposits also indicates the perfection of the fossil record.

The dating of the various peat levels must necessarily be somewhat hypothetical until more information is accumulated, but we can at present state definitely the age of the surface layer and with some certainty the basal levels. The dating of the other levels cannot be made by determining a rate of peat development, as is done by Sears and Janson ('33), and using that as a measurement of time. This is evident when one compares the depth of contemporaneous deposits (Fig. 7). There are many variables that determine peat development and each bog appears to have its own particular rate of building. The use of specific fossil percentage-curves to arrive at even an approximate comparison in bogs of different ages was found unsatisfactory in Douglas County. Even the rate of peat development in a single deposit cannot be considered to have been uniform from its earliest formation. It is reasonable to expect that as a peat deposit matures its rate of formation will be accelerated, because in its early stages the organic sediments are usually much more modified by bacteria and, as the lake-basin with its body of water matures, the organic sediments become coarser and consequently the sedimentation is more rapid. For this reason it is impossible even to compare the various contemporaneous sections. The similarity of certain percentage-curves is significant and these appear to be the best means of age-comparison within short distances. However, this is a successional comparison and does not specify a definite date. As stated above, the greatest difficulty in correlation appears when bogs of different ages are compared and unfortunately this is the comparison of most value in determining the vegetational history of the region. The unsatisfactory attempts to use the rates of sedimentation and fossil spectra as geological time markers leaves only one method of estimating a division of the postglacial time occupied by the lakes in the Lake Superior Basin. This is a comparison of the shore work accomplished by each of these lakes. According to Martin (page 463 l. c.) "it seems possible that the present stage of Lake Superior has not existed as long as did the Nipissing Great Lakes." His evidence for this statement is the amount of shorework left by this lake stage. The beaches are higher and broader than the preceding two lake stages and upon comparison of these and also those of Lake Superior it seems reasonable to conclude that Glacial Lake Nipissing time may be placed approximately half way back to the uncovering of the region from ice. Also, upon a somewhat arbitrary basis, the remaining previous time has been divided one half into that occupied by Glacial Lake Duluth until it fell to the level of Glacial Lake Algonquin, and one half into the time occupied by this latter lake until it in turn dropped to the Nipissing Great Lakes stage. This division is, admittedly, open to some criticism but it does have some supporting evidence and until a better subdivision of postglacial time in Douglas County is suggested this appears to be the best available.

If an examination is made of the fossil spectra from the surface of the bogs in Douglas County and then compared with the map of the present vegetation (Fig. 6) a marked similarity is evident. This close correlation between the fossil spectra and map of the present vegetation is a very good demonstration of the value of the paleoecological technique in determining plant distribution.

Pursuing further the suggestion of the above correlation between the microfossils and plant distribution, an attempt was made to determine the type of forests and their distribution at the time of the various glacial lake stages. An examination of the lowest levels in the depressions, which were in existence during Glacial Lake Duluth time indicates that throughout the county, spruce (*Picea*) forests were dominant. Upon the lighter soils of the county (Fig. 1) an additional tree was important with spruce. This was jack pine (*Pinus Banksi-*

ana). A vegetation map such as that shown in Fig. 2 is suggested by the spectra from the basal levels of the sediments contemporaneous with Glacial Lake Duluth.

A detailed examination of the lowest sample of peat taken from Bog No. 1 shows that among the microfossils present, two interesting plant species occur. These are internal leaf trichomes of Nymphaeaceae, and spores of *Lycopodium inundatum*. It is probable that these plants were distributed almost entirely by water and to make such distribution possible they must have been present in the region very early. It is quite certain that this bog was never connected with Lake Duluth, at least not during the period when the well marked beach was cut at the 1280 foot elevation. It has been shown by Leverett and Sardeson ('32) that the last advance of the glacial front in the region of Lake Superior was not a complete cover of ice over the area and that part of northern Minnesota was free, as well as most of northern Wisconsin. That plants were in existence on this uncovered drift (Substage 3 of Leverett) during the advance of the last ice is suggested by the fossil logs found at Solon Springs, Douglas County, Wisconsin, as already described.

McLaughlin (l. c.) has suggested that *Lycopodium inundatum* and certain species with Atlantic Coastal Palin affinity in northwestern Wisconsin are associated in their distribution with the Glacial Great Lakes. He further suggests that this distribution was an invasion from the Atlantic Coast and Gulf of Mexico during the recession of the last ice sheets and the existence of certain glacial lakes. The presence of the fossils of *L. inundatum* in the lowest levels of Bog No. 1 shows that it was one of the first plants in the region. It seems possible that this plant, as well as others, remained alive within the region during advance of the Mankato Ice. As this ice sheet melted the only source from which plants could enter very early upon the newly deposited soils would be from the north, west, or south and the earliest means of dispersal of seeds or spores by water would begin in the western end of Lake Superior and progress eastward with the melting of the ice in the lake bed. It seems more probable that *L. inundatum* and Nymphaeaceae sp. arrived at the location of Bog No. 1 from the west during the time of Lake Nemadjii or at a brief period of Lake Duluth, rather than over a soil barrier from the south.

The other fossil components of the basal sample of peat are *Pinus* 18%, *Picea* 72%, Gramineae 3%, *Betula* 1.5%, *Quercus* 1%, *Acer*

1.5%, and Compositae 1.5%. This fossil flora is the most varied of any basal deposit examined in Douglas County and it is interesting to note that it is not only one of the oldest deposits in the county but it is also the farthest west and was consequently closest to the source of early plant dispersal if that center was located as is noted above.

A compilation of the recognizable fossil species from the basal levels of peat in bogs of Pro-Glacial Lake Duluth origin suggests the following flora for Douglas County at that time.

Species	Bogs	Species	Bogs
Sphagnum sp.	4	P. mariana	1, 2, 3, 4, 5, 6
Drepanocladus revolvens	3	Abies balsamea	3
D. Wilsoni	3	Gramineae sp.	1
Calliergon trifarium	4	Betula sp.	1, 3
Lycopodium inundatum	1	Quercus sp.	1
Pinus Strobus	1, 6	Nymphaeaceae sp.	1, 3
P. resinosa	1, 6	Acer sp.	1
P. Banksiana	1, 3, 4, 6	Compositae sp.	1, 2
Picea glauca	1, 2, 3, 4, 5, 6		

Additional species, which occur as fossils slightly above the basal level, are as follows:

Species	Bogs	Species	Bogs
Lycopodium clavatum	1	Alnus sp.	1
Salix sp.	4	Ericaceae sp.	1

Reference to Fig. 7 shows that at this period *Picea* forests dominated the county and on the sandy areas *Pinus* early attained importance. Fig. 2 shows a generalized map of this vegetation.

A compilation of the fossils in the basal levels of the two bogs of Pro-Glacial Lake Algonquin origin suggests the following flora in their immediate areas:

Species	Bogs	Species	Bogs
Pinus Strobus	7	P. mariana	7, 8
P. resinosa	7	Betula sp.	7
P. Banksiana	7	Alnus sp.	7
Picea glauca	7, 8		

The formation of these two bogs has been discussed above, and it was pointed out that Bog No. 7 is located upon the highest terrace of the Brule River. When the basin of the bog formed, it was very close to an area that was already covered by forests which had passed the pioneer stage of succession. Consequently, the basal level in Bog No. 7 will include fossils from the adjacent highland as well as the fossils from plants which grew upon the terrace. Bog No. 8 might also present conditions similar to those of Bog No. 7 since it was close to an area exposed when the Mankato Ice disappeared. However, an examination of the pollen spectrum of this bog shows that *Picea* forest alone fringed the shore of Lake Duluth and that this flora remained unchanged while at least four inches of peat was formed in Bog No. 8.

Seven inches above the contact of mineral soil and peat were found a few microspores of *Selaginella selaginoides*. The number of spores of this species increased from 2% of the spectrum at this level (47 inches) to 4.5% at 43 inches, and to 14% at the 39 inch level. It is interesting to note that today this species is found in Wisconsin only on the Door County Peninsula in Lake Michigan, and that the nearest known stations for it in the Lake Superior region are on Isle Royal, and at Grand Marais, Minnesota, and more than one hundred miles northeast of Bog No. 8.

The suggestion made by the percentage of *Picea* in the basal deposit of Bog No. 8, and the predominance of these fossils at the same position in Bog No. 7, appears sufficient to indicate that upon the soils newly exposed by the fall of water level, the pioneer vegetation near Lake Duluth moved north and established itself. This should be further shown when peat deposits in the western part of the county are discovered and studied.

In order to determine the flora in the remainder of the county at Pro-Glacial Lake Algonquin time, it is necessary to establish a level in each bog that will be comparable in time to this lake. The difficulty involved in this procedure has already been discussed and probably the best method at present is to consider that one-half of the peat in the Pro-Glacial Lake Duluth bogs has been deposited since early Nipissing time, one-fourth more during Algonquin time, and the additional one-fourth since Duluth time. A comparison of the basal spectrum of Bog No. 7 and earlier bogs might be made as a means of determining the comparable level, but local conditions make this determination difficult. The following comparison has been made and the plants listed below represent the fossil flora in the county at Pro-Glacial Lake Algonquin time. Species appearing between the Algonquin level and up to that of the Nipissing are included in the list.

Species	Bogs	Species	Bogs
Sphagnum sp.	1, 2, 3, 4, 5, 7, 8	Cyperaceae sp.	8
Polypodiaceae sp.	7, 8	Salix sp.	1, 2, 3, 4, 5, 8
Lycopodium annotinum	1, 7, 8	Betula sp.	1, 2, 3, 4, 5, 6, 7, 8
L. clavatum	1, 3, 7	Alnus sp.	1, 2, 3, 4, 5, 6, 7, 8
Selaginella selaginoides	8	Quercus sp.	1, 2, 3, 4, 6, 7, 8
Pinus Strobus	1, 2, 3, 4, 5, 6, 7, 8	Q. ellipsoidalis (trichome)	6
P. resinosa	1, 2, 3, 4, 5, 6, 7, 8	Nymphaeaceae sp.	1
P. Banksiana	1, 3, 4, 5, 6, 7, 8	Acer sp.	1, 2, 5, 6, 8
Picea glauca	1, 2, 3, 4, 5, 6, 7, 8	Ericaceae sp.	1, 3, 4
P. mariana	1, 2, 3, 4, 5, 6, 7, 8	Chamaedaphne calyculata (trichome)	1
Larix laricina	1	Compositae sp.	1, 2, 3, 4, 5, 6, 7, 8
Abies balsamea	1, 2, 3, 5, 6, 7, 8		
Gramineae sp.	1, 6, 8		

It will be noted that a distinction has been made in considering the fossils of *Pinus Strobus* and *P. resinosa* in the southeastern part of the county. These two species cannot ordinarily be safely distinguished as fossils. However, they are distinct within certain limits when fresh material is studied. In the southeastern part of Douglas County there appeared such an unusual abundance of forms characteristic of *P. resinosa* that this separation was made. It was also possible to do this in Bogs 1 and 2, but instead, *P. Strobus* is the dominating species.

A comparison of the graphs shown in Figs. 7 and 8 seems to indicate that very early in the vegetational history of the county the *Picea* forests gave way to forests of *Pinus*. On the sandy loam soils in the regions of Bogs 1 and 2 this succession was accomplished by *Pinus Strobus*, while on the light sandy soils in the southeastern part of the county it was first *P. Banksiana* and then *P. resinosa*. If one-fourth of the distance from the bottom in the first six bogs is comparable to Glacial Lake Algonquin time, then the vegetation of the county can be mapped as shown in Fig. 3.

It will be noted that the abundance of *Quercus* becomes significant between the one-fourth and the one-half levels from the bottom of the first six bogs. Though this percentage is small in comparison with that of the conifers, the importance of a small rise is significant because *Quercus* and other hardwoods produce comparatively less pollen per tree than the conifers.

With the fall in the water level of Glacial Lake Algonquin and the beginning of sediment-accumulation in the basins of Bogs 9 and 10, a record of the Nipissing vegetation was begun. As at the beginning of the two previous lake stages, the pioneer forests upon the newly exposed soils were composed of *Picea*. These forests appear to have moved north from the area they formerly occupied on the soils exposed by the fall in the water level from the Lake Duluth stage to that of the Lake Algonquin stage. The Nipissing forests also moved out upon that part of the Nipissing plain now covered by Lake Superior. This is shown by the presence of submerged and buried peat beds in Lake Superior.

The fossils in the basal levels in Bogs 9 and 10 indicate that the following plant species were members of the first Nipissing flora.

Species	Bogs	Species	Bogs
Sphagnum sp.	9	P. Banksiana	10
Lycopodium annotinum	10	Picea glauca	9, 10
L. clavatum	9, 10	P. mariana	9, 10
Pinus Strobus	10	Gramineae sp.	9
P. resinosa	10	Betula sp.	9

In a submerged Nipissing peat bed located near the Apostle Islands, in Bayfield County, Wisconsin, a highly complex flora is indicated (Wilson, '35). The peat that was recovered from this deposit does not contain the pioneer vegetation comparable to that in the basal levels of Bogs 9 and 10. Yet this deposit, because of its location, is known to be of Early Nipissing Great Lakes age, and it is definitely known that the following additional plants were in northern Wisconsin at the Nipissing Great Lakes time.

Polypodiaceae sp.
Taxus canadensis
Larix laricina
Abies balsamea
Cyperaceae sp.
Carex crinita
Salix sp.
Alnus sp.
Quercus sp.
Acer spicatum
Ericaceae sp.
Chamaedaphne calyculata
Compositae (four genera)

If the level half way from the bottom of the Pro-Glacial Lake Duluth bogs is to be considered as the beginning of Nipissing Great Lakes time, the following vegetation was in existence within the area first uncovered by ice.

Species	Bogs	Species	Bogs
Sphagnum sp.	1, 2, 3, 4, 5	Betula sp.	1, 2, 3, 4, 5, 6
Pinus Strobus	1, 2, 3, 4, 5	Alnus sp.	1, 2, 3, 4, 5, 6
P. resinosa	1, 2, 3, 4, 5	Quercus sp.	1, 2, 3, 4, 5, 6
P. Banksiana	1, 3, 4, 5	Acer sp.	2, 5
Picea glauca	1, 2	Ostrya virginiana	2
P. mariana	1, 2, 3, 4, 5, 6	Ericaceae sp.	3, 4
Abies balsamea	2, 3, 5	Chamaedaphne calyculata	5
Gramineae sp.	5, 6	Compositae sp.	1, 2, 3, 4, 5
Salix sp.	2, 3, 4		

The fossils present in the Pro-Glacial Lake Algonquin bogs, Nos. 7 and 8, one-fourth of the distance from the bottom, are as follows:

Species	Bogs	Species	Bogs
Sphagnum sp.	7	Picea glauca	8
Polypodiaceae sp.	7	P. mariana	7, 8
Selaginella selaginoides	8	Abies balsamea	8
Pinus Strobus	7, 8	Gramineae sp.	8
P. resinosa	7, 8	Salix sp.	8
P. Banksiana	7		

The above flora with the addition of the plants previously recorded contains all of the important elements of the living flora of Douglas County. The indication is therefore that the present flora of Douglas County is essentially the same as it was in early Nipissing Great Lakes time, with the exception of the European element now present, and possibly some of the aggressive prairie species.

A study of the graphs in Figs. 7 and 8 as well as the tables of the ten bogs shows that at those levels assigned to early Nipissing Great Lakes time the forests were different on the various soil-belts of the same age as well as in the areas of different ages. The hardwoods now appear to have attained importance in the region exposed since Glacial Lake Duluth time. In the sandy loam belt they were probably of greater importance than on the light sandy soils. Upon the area formerly covered by the southern part of Glacial Lake Duluth *Pinus Strobus* was probably the most abundant tree and upon the Nipissing plain *Picea mariana* was the pioneer species. Today, there are still small areas where this tree is dominant on high ground near the shores of Lake Superior. The length of time during which this pioneer forest dominated the newly exposed soils at each lake stage apparently was not long for in practically every bog there is a marked decrease in the relative abundance of fossils of *Picea* a few inches above the bottom deposits. Figure 4 is suggested as a vegetation map for early Nipissing Great Lakes time.

The change from the Nipissing Great Lakes water level to the present Lake Superior level came about very gradually and there appear to have been no radical changes of the vegetation in Douglas County until levels were reached in the bogs that may be comparable to late historic time. This change is marked by an increase in the Compositae fossils and probably does not antedate the forests as they appeared in 1897 (Fig. 5). The marked rise in the Compositae fossils may have been in response to the extensive lumbering operations and fires which resulted in denuding the county of forests and in the uncovering of the soils. Upon these a prairie vegetation has intruded, and some early stages of plant succession have once again started.

An examination of the graphs of Fig. 7 usually shows two levels in the bogs where *Picea* is of marked importance. These are, first, at the bottom of the deposit and, second, at or near the top. A climatic significance has been attributed to this type of curve by some authors, but such a curve is also easily explained by a local succession of trees upon the bogs. It has been shown that the first forests upon the various soils of Douglas County were of *Picea* and the absence of other species of trees easily explains the dominance of *Picea* fossils in the basal levels of each deposit. With the appearance of other species in the region the relative abundance of *Picea* fossils would become less. Then as the lake or pond, in which organic sediments were accumulating, matured to a stage where a *Sphagnum* mat began to encroach upon the water area, *Picea* again would become an important tree, this time as a pioneer upon the organic soils of the bog. The association of *Picea* and *Sphagnum* is clearly shown by a corresponding increase in the microfossils of these species near the top of the deposit (see tables). In a study of limnic and subäerial peat in one bog (Wilson and Galloway, '37) the second rise in *Picea* was found to be contemporaneous with the transition of the peat from limnic to subäerial. In several of the peat deposits a second drop in the *Picea* curve is evident and this might be taken to indicate that the peat itself has undergone modification, such as oxidation, and trees from the upland have become established upon the deposit. There is also another possibility for such a drop. This is a denudation of the bog by fire and an earlier deciduous tree recovery on the upland.

If the several forest trees, which have fossil representation in the peat sections and are indices to the stages of forest succession, are listed as to their relative distance from the surface of each bog where they first reached an important or maximum microfossil percentage, the following very interesting table will be constructed.

A Comparison of the Relative Depth in per cent from the Top of each Bog where certain Fossil Tree Pollens first attained marked Abundance

Species	*Pro-Glacial Lake Duluth Origin*						*Pro-Glacial Lake Algonquin Origin*		*Pro- Nipissing Great Lakes Origin*	
	Bog 1	Bog 2	Bog 3	Bog 4	Bog 5	Bog 6	Bog 7	Bog 8	Bog 9	Bog 10
Ostrya...		.43								
Tilia.....	.37		.43	.00						.00
Quercus..	.54	.43	.59	.77	.41	.85	.60	.00	.57	
Acer.....	.62	.92			.88	.40		.66	.57	
Pinus.....	.87	.87	.87	.88	.88	.92	100	.79	.71	.91
Picea.....	100	100	100	100	100	100	100	100	100	100

It will be noted in the table that the maximum of *Picea* is in the basal levels of all the bogs studied, and that next in order, *Pinus* appears in abundance at almost a uniform level. There is particularly a marked similarity in the occurrence of *Pinus* in the bogs of Pro-Glacial Lake Duluth origin. The basal occurrence of the *Pinus* maximum in Bog 7 can be explained by the geographic location of the deposit. This has been discussed. The first abundance of the other tree fossils also shows marked similarity in their relative stratigraphic appearance regardless of their ages. Such a similarity of appearance might be considered to indicate that there were but brief intervals between the lake stages and that the vegetation did not make a general invasion into the region until near the beginning of the Nipissing Great Lakes. This is necessarily discounted by the great amount of shore work accomplished by each of the glacial lakes, indicating great lapses of time between the stages, by the sharp contacts of peat and clay soils in Bogs 3 and 4, and by evidence which the fossil logs discovered at Solon Springs present as to the proximity of the vegetation to the Mankato Ice border. Instead, the great similarity of appearance may further demonstrate the order and uniformity of the *Picea*, *Pinus*, and hardwood forest succession on the soils of different ages in Douglas County, Wisconsin.

Summary

1. In ten peat bogs of Douglas County, Wisconsin, the microfossil succession has been studied.

2. The bogs were selected with reference to the shorelines of Glacial Lakes Duluth and Algonquin, and the Nipissing Great Lakes in order that a comparison of their fossil spectra could be made and the vegetational history of the region might be determined.

3. A survey of the present vegetation of Douglas County shows that it is definitely related in its distribution to the soils of the county.

4. Comparative studies of the fossil spectra under discussion indicate that upon each area of land that was progressively uncovered by the waters of the glacial lakes there developed a pioneer forest of *Picea*. The subsequent vegetational development upon these areas appears to have been in response to the soils.

5. The general plant succession suggested by the microfossil studies on the heavier soils of the county appears to have been (1) *Picea*, (2) *Pinus* forest, (3) hardwood forests, and (4) mixed second growth hardwood forests with an additional important Compositae element. The general floral succession on the lighter sandy soils appears to have been (1) *Picea* and *Pinus Banksiana* forest, (2) *Pinus resinosa*, *P. Banksiana*, and *Quercus ellipsoidalis* forest, and (3) a second growth *Pinus Banksiana* and prairie vegetation.

6. Changes in certain pollen percentages in the spectra may also be explained upon the basis of some local ecological factor other than climate.

The writer wishes to express his appreciation to Dr. N. C. Fassett of the Department of Botany, of the University of Wisconsin, and to Prof. F. T. Thwaites, of the Department of Geology, of the University of Wisconsin, for their criticism and suggestions, to Mr. W. H. Burrell, Director of the University Herbarium, Leeds University, for invaluable assistance in the early stages of the problem, and to Drs. W. S. Cooper, F. K. Butters, G. D. Fuller, C. O. Rosendahl, and P. B. Sears for reading and criticising the manuscript.

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NOTES ON THE LOBELIAS IN THE HERBARIUM OF STEPHEN ELLIOTT

ROGERS McVAUGH

WHILE in Charleston, South Carolina, in June 1937, the writer had the opportunity, through the kindness of Mrs. Frances Barrington and Mr. Robert Lunz, Jr., of the staff of the Charleston Museum, to examine the Lobelias in the herbarium of Stephen Elliott. The Elliott collection was of special interest because of the uncertain application of the names of several Lobelias mentioned in the "Sketch."[1] "*Lobelia amoena* Mich.," "*Lobelia Claytoniana* Mich.," "*Lobelia puberula* Mich." and "*Lobelia pallida* Muhl." are all included by Elliott, and, as type material of these species has so far not been found, it was thought his herbarium, being nearly contemporaneous with those of Michaux and Muhlenberg, might throw some light upon the identities of the above species. It was hoped to discover also the identity of *L. puberula* var. *glabella* Elliott.[2]

The collection now contains sixteen specimens of the genus *Lobelia*, all from the United States. Following is the complete list:

1. L. CARDINALIS L. No data with specimen.
2. L. SIPHILITICA L. No data with specimen.
3. L. ELONGATA Small. Labelled "*L. amoena?* Mich." and "Hab. in humidis."
4. L. GLANDULOSA Walt. Labelled "in humidis" and with what is apparently a corruption of Michaux's *L. crassiuscula*.
5. L. PUBERULA Michx. Labelled "*L. puberula* Mich." and "hab. in humidis."
6. L. SPICATA Lam., var. LEPTOSTACHYS (A.DC.) Mack. & Bush. Two specimens: one labelled "Carol. Sept. Dr. Schweinitz" and with an unpublished name credited to Schreber; the other labelled "*L. Claytoniana;* hab. juxta Columbiam, S. C., Mr. Herbemont."

[1] ELLIOTT, STEPHEN. A Sketch of the Botany of South Carolina and Georgia 2 vols. Charleston, 1816–1824.

[2] ELLIOTT, op. cit. 1: 267.